SILICON CHIP

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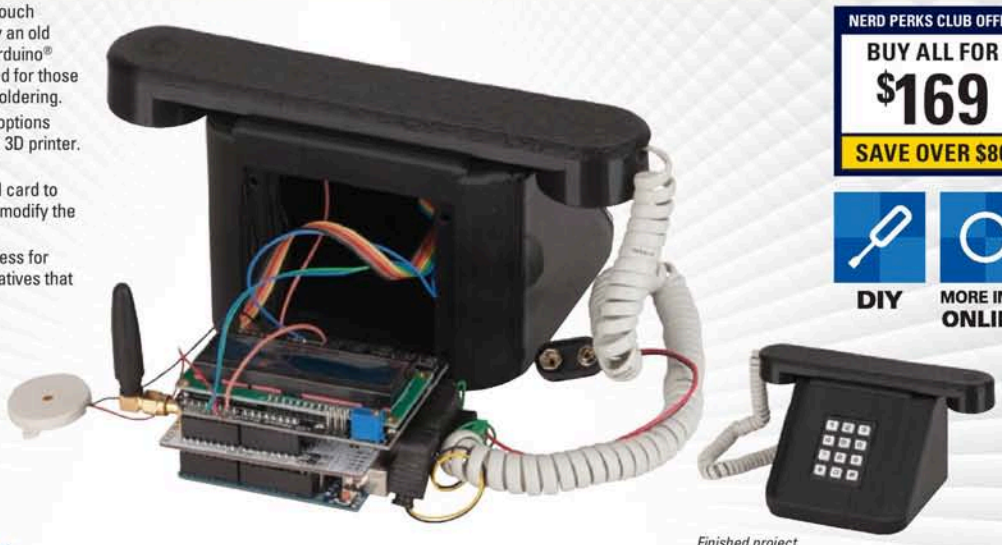

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Publisher's Letter

Taiwan's booming electronics industry

Back in June this year I visited Taiwan as a guest of the Taiwan Trade Centre, in Sydney, as a preview of the Taiwan International Electronics Show, to be held in October this year. The trip involved visits with a group of journalists from other countries to electronics companies in Taipei and Taichung. In all, we visited eight companies over three days and as you might expect, it was a pretty full program which began the same morning as I had arrived (very early) after a very drawn out and delayed journey from Sydney.

Nevertheless, I was looking forward to these plant visits and perhaps seeing some state-of-the-art products and assembly techniques. As the days unfolded, I was not disappointed but at the same time, I was surprised that production line techniques have really changed very little since I was involved in electronics manufacturing in Australia almost 50 years ago.

In fact, in some ways it was quite a nostalgic trip, seeing production lines employing mainly women doing quite similar work to that performed way in the past. Sure, they are now working with tiny electronic components and the test instrumentation is completely changed but the acceptance tests and methods used today are not much different from those used in yesteryear.

And while the machinery used to mass-produce tiny components such as relays, connectors, DIP switches and others which use a variety of metal stampings and moulded plastic parts are more advanced, the processes were very similar, even though the machines tend to be smaller, much more automated and faster – much faster. So the dies used in the stamping presses are made by toolmakers using lathes, milling and grinding machines, just as they were 60, 70 and 80 years ago and you still need teams of technicians to set up, adjust and maintain all these machines so that they can keep running over two or three shifts.

Even the design process does not seem to be all that different. Sure, nowadays designers and engineers are using high-definition screens, CAD/CAM and simulation software instead of working with slide rules and drafting boards but the basic methods are still quite similar. The quest is always to produce a good performing design at low cost – that has never changed.

But while there was a fair degree of nostalgia for me, there was also the grim confirmation that what I saw in three days was but a very tiny picture of what is happening all over Asia and particularly in China. In simple terms, Australia and most other western countries simply cannot compete with mass-produced products from Asia. Nor should you think that products made in Asia are produced in sweatshop conditions by poorly paid workers. They are not.

We cannot compete largely because our wages are much higher than in most of Asia and our currency makes it very difficult for Australian exporters. And of course, it seems that there are many hurdles for anyone trying to set up a manufacturing business in Australia.

All of that said, it is a wonder that Australia is still such a rich and fortunate nation. No, we cannot compete with cheap, mass produced items but really, why would we want to? The rewards go to those companies and organisations who play to their strengths and so many of our businesses do exactly that. And if they don't, they cease to exist.

Finally, there is much to admire in Taiwan, a country with virtually the same population as Australia but lacking our enormous resources. While their GDP is less than half that of Australia's, they have some very impressive infrastructure, including their High Speed Rail which has been running since 2009. By contrast, Australia's roads and rail systems (apart from those run by mining companies) seem rooted in the 19th century at worst and possibly the 20th century, at best.

Leo Simpson

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MAILBAG

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Potential lightning strike tracking article

I recently read about the www.lightningmaps.org website in your article on Atmospheric Electricity in the May 2016 issue (page 25). As there was a storm passing Bateman's Bay at the time, I used that site to see where the lightning was.

As mentioned in that same article, it's possible to build a receiver and co-operate in the effort to track lightning via this website. The station parts cost about 300 Euros or $A450 and I thought that building and getting a station operational could be the basis of a series of articles for SILICON CHIP.

John Keeling,
via email.

Danger running an air-conditioner from an inverter

I recently connected my 1.7kW air-conditioner to a 5kW inverter (off-grid). After a while, the contactor started "pumping" at about 5Hz. Had I not noticed, it could have caught fire.

The inverter's built-in brownout protection did not operate because the relative overload was too short. The air-conditioner's protective timer also did not operate. The thermal protection would not have operated because it's on the motor, not the contactor.

Some possible solutions are: add a microcontroller to SILICON CHIP's Brownout Protector (Mk3 version?) and program it to trip after five occurrences of a cycle loss (so much for keeping things simple!); change my contactor to a solid-state relay or buy an inverter air-conditioner.

In any case, consumers should be warned – air-conditioners near flammable buildings supplied by off-grid systems could be a recipe for disaster.

Paul Smith,
King Creek, NSW.

Comment: the July 2016 Brownout Protector is not intended for use with inverters that may not be able to deliver sufficient output voltage under load if their batteries are deficient. Under those conditions, the Brownout Protector would cycle power off as the load is connected, only to re-connect as the inverter regains voltage under no load. That would not happen with a grid-based 230VAC supply.

In reality, the most effective protection for an inverter in these circumstances would be to have a circuit which monitors battery voltage and simply turns off the inverter if the voltage drops below a preset threshold. However, such a device would need to be able to switch a very large current; more than 200A in the case of a 24V inverter.

Fossil fuels are still a critical resource

Thank you very much for publishing my email regarding the "regulating type" electrolytic capacitor in the Mailbag pages of the July 2016 issue. Thank you too for the information that you were able to find using Google, which helps to explain how this device works.

Now to the main reason I am writing to you: I totally agree with your Publisher's Letter in that same issue. You hit the nail right on the head by saying that everybody on the planet is dependent on fossil fuels.

AM interference from street lamps

With respect to the Publisher's Letter in the August 2016 issue, where I live out at Riverstone there is a massive amount of AM interference which appears to be coming from street lights.

Not all of them seem to be doing it but with the offending ones, as you approach one you start to hear a low buzz that rises to a loud roar as you're actually passing the post. I would imagine that AM reception would be well-nigh impossible in the adjacent houses.

There is a definite background level of "hash" which appears to be all-pervasive in built-up areas. When I was building the "Aussie 3" valve radio project featured in the January 2008 issue of SILICON CHIP, I was initially concerned about the level of noise between stations. I had thought about digital interference but with the house power switched completely off, and the radio run from gel cells and a string of 9V batteries, there was no apparent change.

So then I wondered if it might have some problem with the 6BL8 valves I used, because they were, after all, designed for use in VHF TV tuners and were not "proper" radio valves. I was thinking there might be some sort of parasitic VHF or UHF oscillation going on.

As luck would have it, I had just started working at Dick Smith Electronics and they had a full EMC and RF testing set-up with a shielded room, fancy spectrum analysers and so on. However, the spectrum analysis turned out to be superfluous; as soon as I closed the door on the shielded room, all the background hash promptly vanished! In there, it just had a small amount of hiss.

It wasn't until I went right out in the country, well away from the power mains, that I was able to get noise-free reception. The reason that radio was so noisy between stations was presumably caused by the high gain of the valves used (in the shielded room, it could still pick up a couple of AM stations, which no other DSE AM radio could!).

Keith Walters,
Riverstone, NSW.

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Mailbag: continued

AM interference is rife & difficult to address

I just read the Publisher's Letter in the August 2016 issue on RF hash. As an amateur radio operator, I am only too well aware of the issues and I have been involved in many RF noise problems, including in my own house.

ACMA have only a handful of field officers left and they are really good at their jobs. As with most government departments, they lack resources and provide a service to those that pay lots of money for their spectrum allocation. Unfortunately, that does not include the average punter or amateur radio operators; we are supposed to self-regulate! But try to tell that to your neighbour with his 5kW Chinese-made solar inverter that puts a complete RF blanket on the neighbourhood.

On the other hand, any interference in mobile phone bands or emergency communications is followed up very promptly and resolved by ACMA field officers.

Our local radio club was lucky enough to have a presentation by an ACMA field officer and his stories were nothing short of amazing. One investigation into a product which had the appropriate C-Tick showed that the sample which was submitted for approval was fitted with the appropriate components for filtering but these components were not installed on the products from the actual manufacturing run (cost saving). This example shows that even products which appear to be compliant can be a problem. Not even an educated consumer stands a chance of avoiding these products.

Another problem we heard about was taxi drivers using GPS jammers to make their taxi location invisible to their bosses and the dispatch service. When these GPS jammers are activated, surrounding GPS units are also affected; for example, an ambulance relying on the GPS to get to an emergency patient.

Unfortunately, we have many thousands of different channels for cheap Chinese products to enter our market and there is no effective way of controlling those channels. Even if ACMA was to issue fines and publicise that fact, the problem is much larger and this will not deter individuals from buying cheap products from China.

As for your AM noise in the garage, I had the same problem and, using a small handheld AM radio, traced the source to the roller door controller which was causing interference, even when it was not operating the door! I rang B&D and was at first fobbed off but after some discussion was informed that they would be prepared to sell me the later model control board at $150. I spent the money and got rid of the problem. I still have the old (noisy) boards sitting under my desk but haven't had a chance to run a test with my spectrum analyser.

Unfortunately, I cannot see any way out of this RF problem in the short term unless there is a major communications disaster in Australia which forces the government to put more resources into ACMA.

Erwin Bejsta,
Wodonga, Vic.

I was always puzzled that when the Labor Government brought in the Carbon Tax, which killed off a significant amount of Australian manufacturing, why exports of coal were not taxed. After all, the coal was going to release the same carbon dioxide into the same atmosphere whether burned in Australia or overseas. This action confirmed to me that the Carbon Tax had nothing to do with Global Warming (or Climate Change) but was just another money grab by the Government from all Australians.

David Williams,
Hornsby, NSW.

Intelligent remote control project proposal

As I was sitting watching TV, I noticed that my remote control fast forward button was failing and I thought of a possible project for SILICON CHIP. I record a lot of TV and time-shift my viewing to suit my lifestyle. I have six remote controls and have tried reducing the number using a programmable unit but this was not altogether satisfactory as it could not combine all of the functions I normally use.

All remote controls also suffer from poor ergonomic design, with the buttons too small and badly placed. So what do I really want in a remote control?

For TV, I want volume up and down, mute and channel change up and down. For replay of recorded programs, I want play, pause and stop. For anything else, I can revert to the usual remote control.

The most important feature required is advertisement bypassing while watching recordings. Currently, I achieve this by pressing the fast forward button several times to get x32 (or x64) fast forward. When the advert is finished, I hit the button again to revert to normal watching. It's no wonder that the fast forward button wears out quickly.

So my proposed remote control needs some intelligence, possibly run by an Arduino Uno. There are 12 or 16-key keypads, as well as infrared sensors readily available. The button layout (subject to review) would be, down the righthand side, mute, pause, volume up and volume down and at left, ad rewind, ad fast forward, channel up and channel down. The middle column could have four fast forward ad buttons.

There is a pattern to the advertisements used on TV. The basic length is 30 seconds and multiples of this are used for all advertisements. Two 15-second ads are sometimes combined. Often a station promo or news update, usually 30 seconds, is added to the block. Usually, several modules are strung together at regular intervals. For instance, SBS documentaries use an 11-module (5:30) group at start and finish and three 9-module groups (4:30) at equal intervals during the program.

Pressing one of the "fast forward ad" buttons would transmit five or six fast forward codes. There would be a timed pause for the required module count, as determined by the length of the advert, and then playback would

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Mailbag: continued

EMI is becoming a serious problem

Your Publisher's Letter about radio frequency interference (RFI) in the August 2016 issue is timely, as it is a serious issue that is getting worse and the problem must be addressed before it is too late. It is not only the AM broadcast band that is being affected; the problem exists right across the High Frequency (HF) spectrum and even into the Very High Frequency (VHF) spectrum.

The problem, as you rightly say, is caused by unintentional and spurious emissions from a wide variety of digital devices. I would also suggest that it is caused by intentional emissions from devices like network extenders and similar devices that use domestic 230VAC cabling for communications in place of dedicated network cabling or WiFi.

While many of the unwanted emissions from devices like power supplies can be fixed by installing appropriate suppression components, it seems that lowest possible cost is the driving consideration rather than good engineering practice. However, some devices, like the network extenders mentioned above, are bad in principle because they apply HF carriers to cabling that is not capable of conveying the signal without significant radiation occurring. And once the signal is propagating as an electromagnetic wave, no amount of suppression in the device will prevent it.

While such devices may be convenient, legitimate users of the HF and VHF radio spectrum pay a high price by way of a rising noise floor and interference that can render impossible the reception of desired signals.

Australian standards exist which cover many of these interference issues but it appears that such standards are often ignored and non-compliant devices are openly sold because they are less expensive than devices that might comply. The average user knows nothing of the potential such devices have to interfere with radio communication systems and remains blissfully unaware of the pollution these convenient devices cause to the RF spectrum.

My observation is that it will take a lot of complaints, polite persistence and many letters to the responsible bodies, Federal Minister and Members of Parliament before the situation changes. Your Publisher's Letter is a very good start; please keep up the pressure over this issue.

Dale Hughes,
Flynn, ACT.

be resumed. The five (or eight) buttons would select the time to skip, covering from say 30 seconds to five minutes. The timing is not critical, so if the 3-minute button was pressed, it would suppress SBS adverts. But if the timing was too long, some dialogue would be missed. If too short, the end of the advert train would appear. This is probably not critical.

If a 16-key pad were used, there would be extra module keys and perhaps a set key. If a small Arduino module, or even just the chip was used, the cost would be reduced.

David Tuck,
Yallourn North, Vic.

Editor's response: a majority of people would agree that most remote controls have drawbacks, with the buttons being too small the most common complaint. However, that is because remote controls typically have lots of functions and so need lots of buttons.

Actually, we don't think that designing yet another remote control with large buttons and limited features is the answer. Perhaps a better solution would be to design a programmable remote with a large touchscreen and no buttons. To control a particular appliance, you would touch the icon for that unit and it would then show a touch panel to suit.

Such devices are sold commercially but at very high cost; we may be able to come up with a project to build one at a much more reasonable cost. With a reasonably large touchscreen, say 5 or 8-inch, the buttons could be large,

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Mailbag: continued

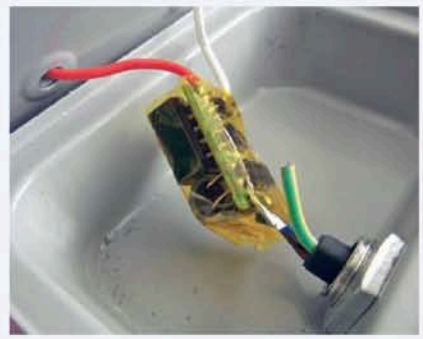
Mains-powered LED lights can be a safety hazard

I recently bought a 10W LED Floodlight on eBay from an Asian seller which had a potentially dangerous wiring defect inside. The very short (plug-less) 230VAC supply lead entered the case and was attached to a flimsily-insulated switch-mode supply module, soldered to and hanging from the Active and Neutral leads, with the Earth lead snipped off, thus leaving the metal body unearthed.

The unit did not have any name or details on it. I have sent a warning note to the supplier who was probably unaware of the unsafe wiring and doesn't appear to understand what I was pointing out!

Name and address supplied but withheld at writer's request.

Editor's note: we are now of the opinion that buying any 230VAC product from an Asian supplier is a risky transaction. If you buy a product from an Australian supplier, even though it will inevitably be sourced from Asia, you at least have the Australian consumer protection laws to fall back on, in the event that you have been supplied with a defective or unsafe product, which this one clearly is.



multi-coloured and importantly, the screen backlighting would mean that they are highly visible, even in the dark.

To avoid the need for a huge amount of programming, the touchscreen remote would need to have a learning feature so that all button functions could be loaded easily. Anyway, that would be our concept. The question is, would the likely cost of such a project, possibly around $150 or so, be an attractive DIY project for our readers?

The biggest obstacle would be that most people now have smartphones and there are numerous apps available to provide this sort of function.

Circuit Notebook criticism & comments on magnetos

Regarding the Circuit Notebook contribution "Precision Resistance Matching Bridge" on pages 70 & 71 of the July 2016 issue; I don't want to rubbish somebody else's work but I do see some problems with this design.

I have grave doubts that the circuit would actually be very accurate in matching resistors. To work properly, the switches would have to have zero contact resistance, or at the least a consistent resistance however small it might be. Both are almost impossible.

Also, having played with a bridge doing something similar, I found it necessary to reverse the polarity of the meter and average the reading. Not all meters, especially cheap ones, have an accurate zero setting.

I would also like to comment on the letter on magneto circuitry in small, portable engines on page 8 of the same issue (Mailbag).

About 20 years ago, I was a Briggs and Stratton service dealer, just when they started to introduce "point-less" ignition systems. Imagine the surprise when we ordered a new coil for an engine only to find that the factory had forgotten to fit the wire going to the points.

B & S were duly contacted and about the only information we could get was, "That's OK, those coils don't need points now".

"Well, how does it know when to fire the spark plug?"

"It reads the position of the rotating magnet in the flywheel and that's it."

"How does it do that?"

Either the people we were talking to didn't know or had been instructed not to reveal the proprietary secret of what is inside the coil. Never having had one of these coils fail, I never got the chance to cut one up and see what was inside. However, I did eventually learn something very interesting about these systems.

To safely hand-start a small petrol engine, the spark must occur about or just before top dead centre; you can break your arm if it is too early. But when running, the engine performs much better if the spark is much earlier (in mechanic's terms, the spark timing is advanced). The nature of the magnetic flux rotating caused the coil

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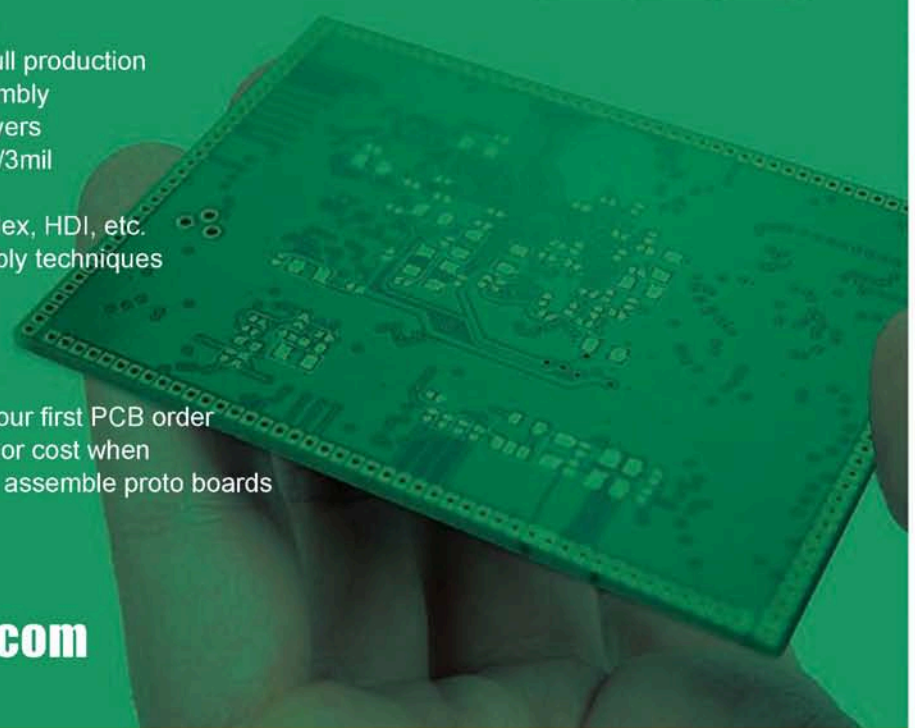

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Mailbag: continued

Older mains power filters can trip RCDs

The Serviceman's Log in SILICON CHIP, May 2016 had a story about an oscilloscope that popped the Earth leakage protection circuit but worked fine when run on an isolating mains transformer. He mentioned that he suspected a fault in the mains filter but when he replaced that, the fault remained.

I think this is due to the fact that, in the past, designers of mains filters did not have to be concerned about Earth currents. These filters typically used a π C-L-C filter in the two mains conductors, with the capacitors connected at one end to the Earth wire. If the capacitors were each nominally 0.25μF, then the capacitor charge/discharge current in the Earth wire could exceed 30mA; enough to trip an RCD.

I don't have access to a circuit diagram of this scope but the story has a familiar ring. I came across a similar problem when a filter for a screened room failed the newly-introduced mandatory annual mains safety check (if you aren't familiar with screened rooms, they are basically a big Faraday cage.) The solution was to use an isolating transformer and to make sure that the separate Earthing rod we used with the room was maintained and not disconnected.

I also had to document this approach in a file, including my authorisation for the "fix" – just in case something went wrong and the management needed a scapegoat. The room was designed for use from 100kHz to 10GHz so it was a multi-section filter with a lot of capacitive bypassing, hence some quite large capacitance values.

I'm sure quite a bit of good gear went to landfill because it was deemed to be unsafe; condemned without a fair hearing I say.

Ron Cook,
Hughesdale, Vic.

to fire earlier as the speed of rotation increased. As a result, B & S were able to increase the horsepower rating, at top speed, without altering the swept volume.

I imagine that in the past 20 years or so, other manufacturers have figured it out and probably improved on the system. I hope this helps to understand what is going on even though I don't know what actually reads the magnet position.

Finally, I don't think the magazine is doing enough to encourage beginners in the electronic arts. It's not much good building a fancy clock or a Brown-out Protector if one does not understand the basic principles upon which they depend. That aside, I would like to say keep up the good work.

Graeme Burgin,
Ararat, Vic.

Learning to program microcontrollers

I am writing in response to the Mailbag comments on the challenges of programming microcontrollers (page 6, July 2016 issue). Firstly, let me say, as an electronics hobbyist of nearly 25 years, that I love your magazine.

With regards to the issues raised by Cliff King, I have to say I agree. For those who do not have any programming experience, I can see how learning your way around a new platform such as the Micromite, Arduino or Raspberry Pi can be daunting. I am fortunate enough to work in the Information Technology sector and have had exposure to many scripting and programming languages over the years, so this is not such a big hurdle for me.

I would like to suggest an expansion on the idea put forward by Cliff. Perhaps you could do a series of tutorials on programming microcontrollers, showing how the same functions can be performed in each of the current popular systems, eg, MMBasic, Arduino & Python (on the Raspberry Pi).

I also recommend that anyone unfamiliar with how a program is put together for their chosen platform should look for a reference document for that particular programming language.

Tony Cook,
Blacktown, NSW.

Comments on Micromite, electronics re-use & model trains

The Publisher's Letter in the April 2016 issue was interesting and deserves some comment. It is quite possible that none of the current experimenter's computers will be used in the future. How many people can remember the S-100 bus? The BASIC Stamp dominated for a while and now it is just one of a large number of "stamp-format" computers. The Arduino, Raspberry Pi and Maximite/Micromite will almost certainly follow the same path.

Although all three systems are good, I prefer the Micromite, as it has many desirable features: the processor and interpreter code are readily available, no special PCB is required, the BASIC language is easy to understand compared to most other languages and there are an enormous number of BASIC programs for inspiration.

I assume that many of the younger generation would be unaware that in the early days of computing, almost all computing and electronics magazines published their program listings in BASIC. As well, companies such as HP, Tektronix and others provided programs for their equipment in BASIC. Even today, there are many current BASIC variants whose proponents post code which can be adapted to the Micromite.

But there is an even bigger feature which all three offer and that is being able to create almost anything that is on the market today (plus totally new things). Instead of buying short-lived, badly designed, unrepairable and difficult to use "goods", it is now feasible to make your own. It is also feasible to replace controllers in existing goods. And if someone has a great idea which needs a controller, any of these microcomputers may allow the idea to be realised.

Then there's the question: at what point do hobbyist computers become so complex that they are beyond the capabilities of hobbyists?

It is interesting to note the success of the Maximite/Micromite which mirror the hobbyist computers of the 1980s. Aside from the technical differences, the mental requirements are similar. There is no need to obtain an electronics/computing degree to be able to use them. The level of complexity is not

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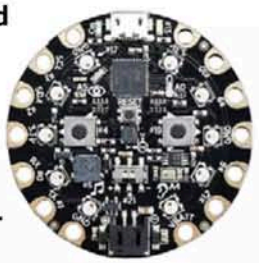

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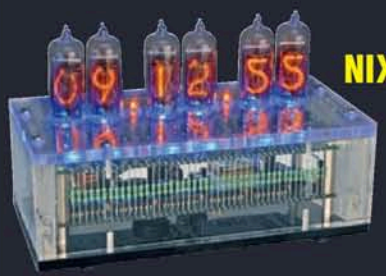

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Mailbag: continued

Yagi antenna provides excellent FM reception

I have just completed the construction of your 5-Element FM Yagi antenna, described in the October 2015 issue. I have an old European Philips valve radio (model B5X92A) which tunes from 87.5MHz to 100MHz. I'm fortunate that most of the stations where I live seem to be in this portion of the FM band.

I live in Pottsville, a small coastal village about 35km south of the Queensland/NSW border, and prior to building the antenna, reception in this area was very poor; you just couldn't be bothered to tune into any stations as they were all just barely audible.

Now I just can't believe the difference. The Philips radio has a "magic eye" which never showed any movement when trying to tune in a station but now the signal strength has improved so much that there is no gap between the two fluorescent halves of the magic eye. Even better is the quality of the sound; just unbelievable! I'm very impressed with this antenna and it was well worth the time spent in its construction. I urge anyone thinking about building this antenna to do so; you certainly won't be sorry.

I have been interested in electronics and radio for many years, since buying Radio & Hobbies at school in the mid-fifties, and still enjoy the various articles that you publish. Keep up the good work and congratulations to you and all of your staff on a marvellous magazine.

Gordon Wiseman,
Pottsville, NSW.

too much. So will that change in the future? I doubt it.

Not only is the human species remaining at its current level of intelligence but also children are still being born with no programming skills just like their parents. The computers and languages that appeal so much to the parents appeal to their children for the same reasons. In my opinion, there is no compelling reason to expect future hobbyist computers to deviate greatly from the current format and complexity.

Regarding component reuse, I was given a dead Samsung LED TV a little while ago which I intended to pass intact to my electronics recycling friend. However, I was curious and decided to look at the electronics. I decided to keep it when I saw the LED backlight. There were 10 strip PCBs with six white LEDs (plus diffusers) on each. Now I have the LED strip light for my keyboard for when I don't want to turn on the room light or when it's a dull day. It's nice to reuse things that otherwise would be rubbish.

Now I have a project idea. I was talking to my neighbour who has become interested in model trains. He wants to include an engine turntable in his set-up but when he mentioned it at a local hobby shop, the experienced hobbyists told him that it was a very difficult thing to do because of the problem of track alignment. Well, I disagree. I have previously implemented precision rotary positioning by

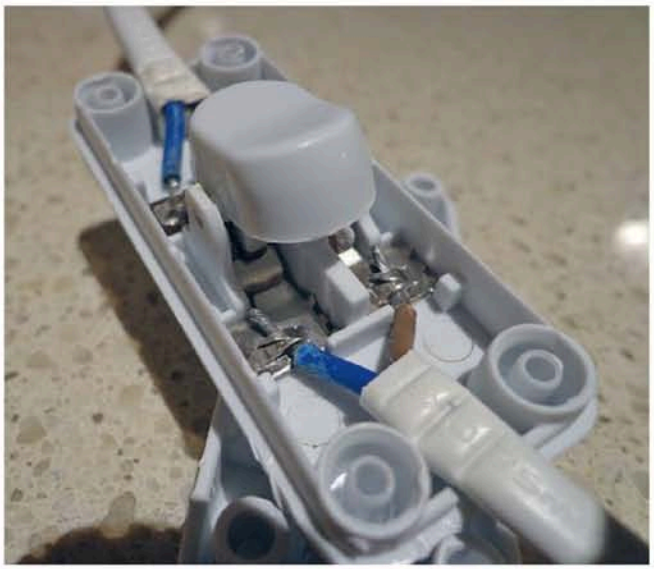
using a stepper motor and a roller type detent.

My neighbour is not deterred and intends to make one. In the meantime, I have decided to watch and do nothing unless asked. But I thought I would bring it to your attention. Both the programming and the electronics are not difficult but a suitable stepper and drive train may not be available at a reasonable cost. The stepper does not need to be big and powerful but it is mandatory to have gearing with almost no backlash and cheap precision gearboxes are not readily available.

George Ramsay,
Holland Park, Qld.

Editor's note: a range of geared stepper motors are available at reasonable cost on Ali Express and eBay. These are commonly used in 3D printers, laser cutters and similar devices which are becoming quite popular.

Mains switch construction less than satisfactory



Just recently, we had our grandchildren with us for the school holidays. In their bedrooms were two bedside lamps that we purchased about a year ago. They worked OK up until last week, when our six year-old grandson told me that the lamp in his room was flickering on and off and was arcing in the cord-line switch, which he had been flicking off and on to try to fix the issue himself.

I found the same problem and on further investigation I found that the cord-line switch is easily separated with the aid of a small screwdriver, to reveal its inside. Once opened, a gentle tug on the blue Neutral wires revealed that they are a simple crimp fitting and that they were loose and blackened. This was the cause of the arcing and presumably would lead to heating of the joint. Further persuasive tugging on the brown Active wire also made it come loose.

I feel that a switch of this type and construction is surely not within Australian Electrical Standards but I may be wrong. Attached are a few photos of this switch and amongst them you can see the standards markings on the rear of the switch in question.

Not being satisfied in throwing the lamp away, and

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Mailbag: continued

Articles on programming the Micromite & Maximite

I would love to see a series on programming the Maximite. I have owned a couple of them and a Raspberry Pi. I prefer the Maximite since it has an ADC and I am able to monitor voltages without a lot of extras.

I love the help the Maximite forum gives. I had never programmed a microprocessor before but within minutes was able to make LEDs flash and monitor voltages on an LCD screen. It needs a relay module as I killed my first one trying to drive relays.

The main problem I had is that firmware updates would change basic things and I then had to relearn where to place files, how to get back and forwards and where things were stored. I would really like to know how to do graphics and display images. There are some very clever people on the Backshed forum, doing brilliant things with the Maximite.

Thanks for a great magazine.

Martin Heppenstall,
Portland, Vic.

possibly the other one we purchased (which also had loose wires at these crimp points), I went to the local hardware store and purchased two HPM D5MWE Cordline switches and replaced the faulty ones.

Interestingly, on the rear of the HPM Switch it says in very small print "Assembled in China from components manufactured in Australia", which made me wonder why we had to make the parts here and send them to China for it to be assembled and sent back here for me to purchase.

Brian Collath,
Moss Vale, NSW.

Loving my new Senators (no, not the ones in Canberra!)

As I write this, it is just over 24 hours since I finished building my first pair of Senator stereo speakers, the first set of speakers that I have built since the 75-litre 3-way system described in *Electronics Australia* nearly 40 years ago! I started out intending to build just the "budget" version but using the Celestion CDX-1730 compression tweeters and Altronics woofer. I also decided to build the boxes myself and so I purchased the parts and set to work.

I found the boxes very easy to build (apart from the fact I got caught by the incorrect dimensions in the first article, having cut the material before the corrections were published) and since everything went together very well, I asked my brother-in-law (who is a professional furniture polisher) to finish them for me in a satin black.

It was while this was happening that, in a moment of weakness, I decided to "go the whole hog" and ordered two Celestion NTR10-2520E woofers. They duly arrived and yesterday I set to and fitted it all together. They look magnificent and may I add, they sound absolutely terrific to boot, with sweet crisp highs, clear midrange and tight bass. I assume that after a bit of "running in" they will become even better.

At the moment, they are being driven by my Pioneer surround sound amplifier which is fed by a Marantz CD6003 CD player, all as part of the lounge entertainment system. However, this is only the start of a dedicated music system that I am in the throes of building. Eventually they will be driven by the 20W Class-A amplifier from SILICON CHIP, May-August 2007. I have the power amplifier modules, power supply and speaker protection module built, tested and adjusted while I wait for the preamp and input selector module kits and the case from the Ultra-LD Mk.3 project to arrive.

I also have a very nice vintage Philips CD-303 CD player being repaired at the moment, to complete what I hope will be a very nice music system. And what am I going to do with those spare Altronics woofers that I ended up not using? I will build a second set of the truly Budget Senators for the family room stereo system. I'm sure they will sound a whole lot better than the decades-old speakers currently in use.

I'm having the MDF cut to size for them right now. I also think I was very lucky in getting what must have been the last four 2.7mH chokes in existence from Jaycar. Thanks for a great sounding speaker project and keep up the good work.

By the way, those old 75-litre 3-way speakers were driven by the 50W/channel Mosfet amplifier that I built from *Electronics Australia* in 1980/81. It was also fed by a Philips CD-303 and did sterling service until I upgraded my stereo in about 1998.

Peter Clarke,
Woodcroft, SA.

Using existing dwelling telephone wiring with the NBN

At last, the NBN is available in my area. I live in the northern suburbs of Wollongong, NSW so I will get the fibre-to-the-node (FTTN) system. With a previous ADSL speed of 5Mbps download and 1.8Mbps upload, I was keen to get connected.

I chose to stay with Telstra but their representative told me that I could not use my existing phone wiring but should plug my cordless phone into the green socket in the modem. I wasn't convinced this was true, so I separated my incoming line to make a direct feed to the modem's internet socket, leaving the wiring in my dwelling isolated.

I then connected a standard phone lead to a phone socket near the modem and plugged the other end into the green telephone socket on the modem. Everything worked well. A speed test with only the internet connected gave a 23Mbps download and 5Mbps upload. Connecting the phone system did not slow the internet speeds.

My phone system comprises two ordinary Telstra phones, one pair of Panasonic cordless phones and an old rotary-dial phone. The dial phone rings OK but of course can not dial out, so I bought a dialgizmo from Zanikan Pty Ltd in Melbourne at a cost of $US39.95 (www.dialgizmo.com/index.html).

This is plugged in series with the phone cord and converts the decadic or loop disconnect pulses to tones, and it works really well. So with the NBN connection I can still use all my phones as normal but with a faster internet speed. The Fibre To The Premises (FTTP) system uses the same modem after the fibre decoder box and would work in the same way.

Julian James,
Coledale, NSW. SC

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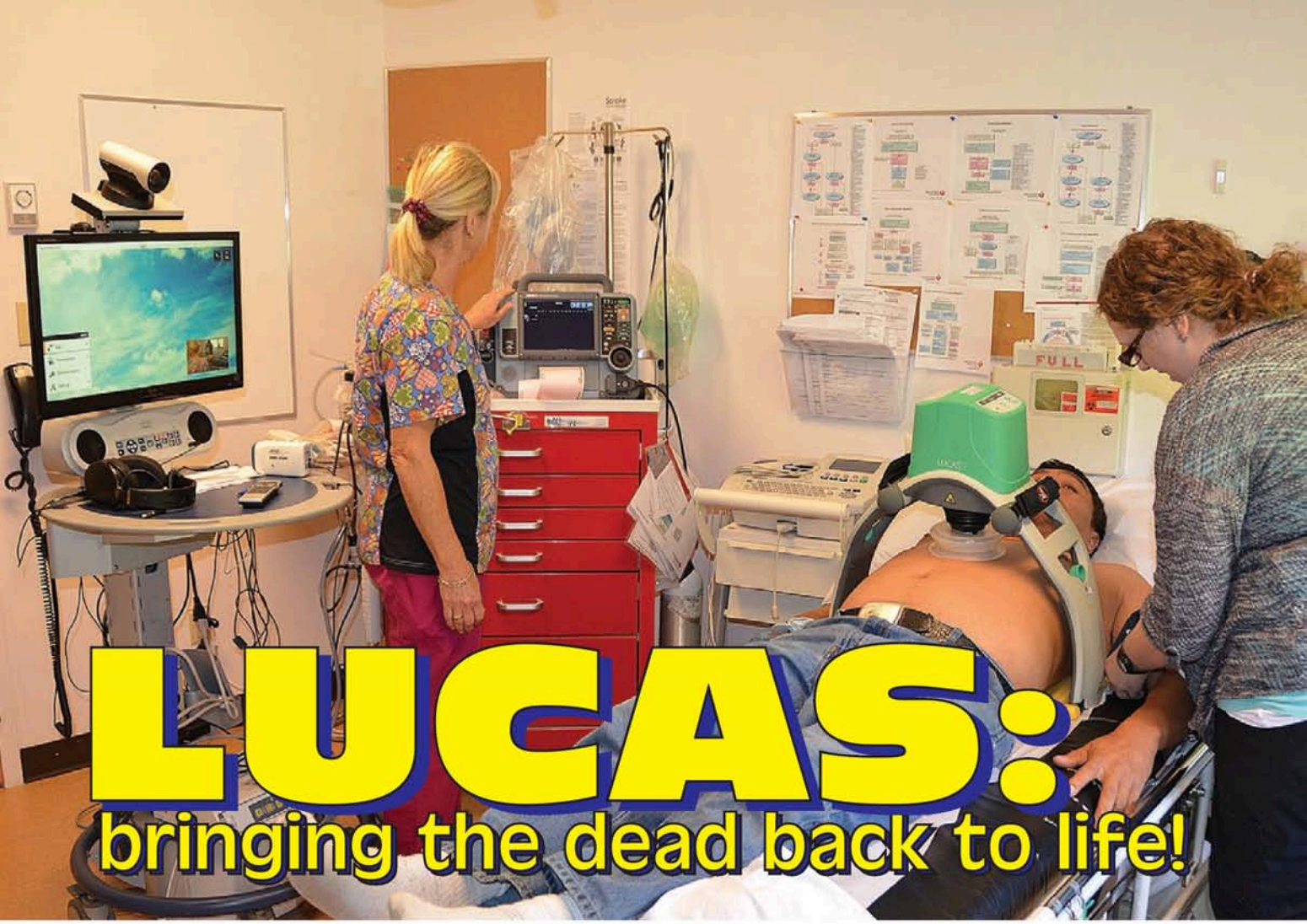

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But as we explained, CPR is not only seldom done correctly, it can very quickly exhaust the persons doing it. Now there's a CPR "machine" which not only does it correctly but it never gets exhausted and has achieved some rather spectacular successes when used.

We're talking about LUCAS, a mechanical device which administers CPR to a person in sudden cardiac arrest, continuously. It does it better than humans can and it will continue for as long as needed.

There are well-documented cases of apparently "dead" people being brought back to life an hour or more after their heart stopped beating. That's significantly longer than the vast majority of CPR administration, although there are some celebrated cases of MUCH longer (successful) manual CPR.

LUCAS was developed at the Lind University in Sweden (hence the first two letters of its name!). The full title is Lind University Cardiopulmonary Assist System (small wonder it's abbreviated!).

by ROSS TESTER

In effect, it is a mechanical plunger which is placed directly over the person's heart and powered by either compressed gas (such as the oxygen carried by all responders) or by internal batteries. It pushes down on the chest a precise amount at a precise speed.

That speed is important, because the heart needs to be compressed frequently enough to provide sufficient blood-flow to keep the vital organs (especially the brain) perfused with oxygen from the lungs.

The reason that LUCAS is so much better than a human in this regard is that LUCAS keeps going and going at a consistent speed; a human tires rapidly (in as little as a minute) and not only does the speed drop but the depth of compression reduces too.

What does it look like?

LUCAS comes in two sections, including a slightly concave piece which lies underneath the person being resus-

LUCAS, seen on the opposite page on a patient in an emergency room, is assembled from two halves: the yellow backboard, which is passed under the patient, and the top portion which contains the LUCAS machine itself. When the two halves are clipped together, the plunger rests on the patient's chest. When activated, the pluger compresses the chest (and therefore the heart) against the backboard at a rate of 100 times per minute.

citated. Clipping into this is the main "works", mounted on a curved frame. The idea is that the curved frame and the bottom piece encompass the victim, with the assembly strapped in position so that it doesn't shift.

Mounted in the centre of the top curve is a solenoid-type device which does the resuscitating. It actuates precisely 100 times per minute at a duty cycle of 50%, pushing the "plunger" out of the machine down to a depth of 50mm. The plunger can be moved up and down to take into account differing body sizes.

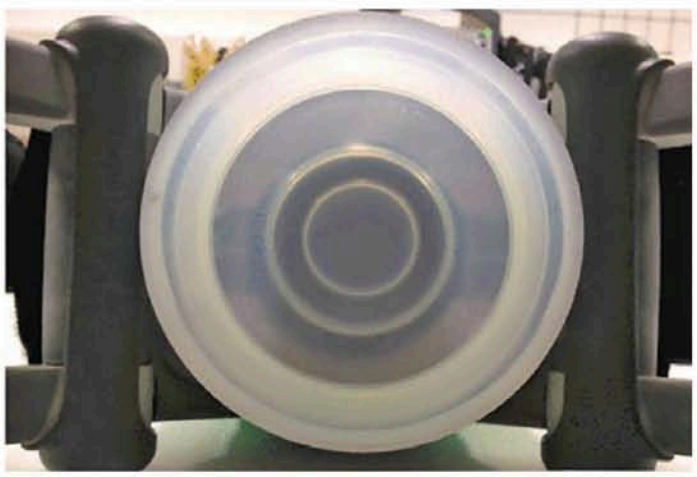
At the end of the plunger is a soft suction cup – it looks similar to a drain-clearing plunger but is made from flexible silicone material. The idea is that this forms a partial vacuum with the chest underneath, to help it "pull up" just as a normally-breathing person's chest rises and falls but also assists in keeping it located.

Once adjusted for position, the plunger operates continuously. This is important in keeping up the blood pressure – not only to the brain but also to the heart itself.

The absolute minimum "coronary perfusion pressure" (or CPP) required to return the heart to spontaneous circulation (or ROSC) is usually quoted at 15mm Hg (Hg=mercury, equivalent to 2kPa). One of the reasons that manual CPR, by itself, has such a low success rate is that it only maintains a pressure of around 15-50mm Hg – IF the CPR is maintained *continuously* and maintained *correctly*. Even 50mm Hg (~7kPa) is barely enough to perfuse the brain and other organs, though it is much better than nothing at all.

One of the main difficulties in doing this is that CPR is so tiring that the first-aider usually cannot continue for more than a couple of minutes and all CPR training includes the mechanism for swapping operators.

However, the action of stopping compressions and changing to a fresh person causes the pressure to drop very quickly to very low levels and it takes a while to build it back up again, even to the lower level quoted above.



The "business end" of LUCAS: this suction cup plunger pushes down on the chest and assists in bringing it back up. As well as maintaining blood flow . . .

. . . this is likely to leave quite a mark! The patient here is shown with defibrillation pads also in position.

One study on pigs (used because of their similarity to humans) showed that with interrupted CPR, CPP fell from 60mm to 15mm HG in just 15 seconds and continued to plummet into negative values until CPR was restarted. Even then, it took 90 seconds to get the CPP back up to the absolute minimum 15mm Hg pressure.

No interruption

By contrast, in its "continuous" mode, the LUCAS machine simply keeps on going, delivering deep compressions (which increase blood pressure) at a steady rate (which maintains increased blood pressure).

LUCAS is able to maintain a CPP of 80-90mm Hg (11-12kPa), virtually an impossibility with manual CPR.

Studies on pigs showed that those which had LUCAS resuscitation had 100% recovery, while those being given manual CPR had only 25% recovery.

It doesn't tire unless, of course, the 25.9V, 3.3Ah lithium polymer battery (or air supply, depending on model) runs out – in which case, a spare battery or new air supply are fitted, which takes but a few seconds. (LUCAS can also operate with an external power supply. It will recharge the battery as well as power the compressions).

Running time is quoted at 45 minutes from a fully charged battery but this will obviously be extended significantly if externally powered. Recharging from flat is quoted at 4 hours maximum but longer if the supply is also powering the LUCAS too. As well as the mains supply, LUCAS also comes with a 12V DC power cable to use in a vehicle (such as an ambulance or even a first responder's vehicle).

30:2 resuscitation mode

In addition to the continuous compressions mentioned above, LUCAS will also operate in the "old" mode of 30 compressions to two breaths administered to the mouth by the first aider (the R – resuscitation – in CPR) .

However, modern guidelines eliminate the pause for mouth-to-mouth breaths but use continuous compressions because it has been found that the pausing compressions for two breaths is in itself a cause for the pressure to drop (as detailed above) – the compression and release of the heart also causes the lungs to allow oxygen to enter the lungs and therefore the bloodstream.

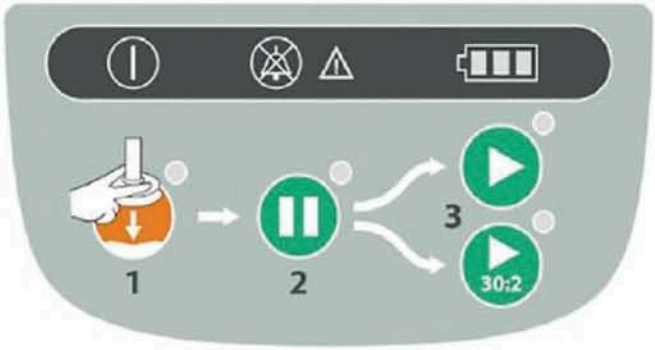
LUCAS compressions should only be stopped to allow a defibrillator (or other ECG equipment) to analyse and if necessary, shock the patient. A "Pause" button on the operating console makes this quick and easy.

The defibrillator pads placed in their normal locations (top right of chest, lower left side) do not interfere with the LUCAS compressions.

Mobile operation

Once the LUCAS machine is fitted to a patient, it can start work – and that includes someone being carried on

All personnel using LUCAS need thorough training, not only in its operation but on the damage it may do if used incorrectly. Here ambulance paramedics are fitting a resuscitation mannequin with LUCAS.



Once fitted, LUCAS operation is very simple and is controlled by this panel. (1) tells the operator to adjust the plunger depth. (2) is the universal symbol for a pause – for example, to fit defibrillator pads etc, while the (3) buttons give you the choice of continuous (100 pulses per minute) or 30:2 resuscitation modes.

a stretcher or trolley, in the back of an ambulance, even being ferried by a rescue helicopter.

Performing manual CPR on someone being transported is notoriously difficult. On a stretcher, it's almost impossible and even in an ambulance rushing to a hospital there is a great risk to an unrestrained CPR-giver.

What are the negatives?

Manual CPR has a real risk of broken ribs. Studies have shown this occurs in about one third of cases; indeed, the sternum is fractured in almost 20% of cases.

Normally this would not be regarded as a problem, the philosophy being a live patient with a few broken ribs is certainly better than a dead patient with a pristine ribcage!

The LUCAS machine can be criticised for the fact that there is no feedback; LUCAS just keeps going. When a manual CPR-giver hears (or sometimes feels) cracking ribs, he/she can adjust their position slightly to minimise dire consequences.

(As an aside, when I did my CPR training many years ago, the old St Johns instructor told the class that "done properly, CPR will inevitably break a few ribs. Done improperly, those broken ribs could be pushed into the heart or lungs and kill the patient").

There are limitations on the physical size of the patient, mainly due to the difficulty of getting the LUCAS secured.

Taken from the LUCAS manual, this demonstrates that operation is possible even when transporting a patient on a stretcher or trolley; even down stairs in this case (something which is not possible with manual CPR).

It is not suitable for young children nor patients with a chest width greater than 450mm.

Cost

The other drawback is cost. While the price of the LUCAS machine depends on the model chosen, you can work on a figure of at least $15,000 per machine. Equipping all 850 ambulances and more than 100 hospitals in NSW alone would cost around $15 million.

They're not likely to be required equipment in sporting clubs, surf lifesaving clubs and so on – they would continue to use traditional CPR until the LUCAS-equipped ambulance arrived.

Even taking these negatives into account, there is much to recommend the LUCAS machine – just ask the people who are living and breathing right now whose lives have been saved (including one woman clinically dead for 57 minutes; fortunately for her she was in the emergency room at a Sydney hospital which had a LUCAS machine!).

LUCAS machines have been installed in a two-year trial between St Vincents and Royal Prince Alfred hospitals and NSW ambulances. (It was RPA hospital where the patient above suffered sudden cardiac arrest).

So far the results have been more than encouraging – RPA Hospital Emergency Department Acting Director Dr James Edwards is reported to have said "We have moved from resuscitating the alive to resuscitating the dead!"

It has even reached the point where, due to the amount of oxygenated blood being pumped to the brain by LUCAS, patients have effectively regained consciousness even before the heart has started beating by itself. That's something rarely, if ever, achieved without LUCAS.

For further information, see: www.lucas-cpr.com

An alternative: the Zoll AutoPulse

A somewhat similar product to LUCAS is the Zoll AutoPulse.

The big difference between the two is that the Autopulse squeezes the entire chest through the use of a load-distributing "LifeBand", which Zoll claims delivers high-quality compressions with much less risk of broken ribs or sternum.

The other main difference is that the AutoPulse operates more slowly than LUCAS, delivering 80 compressions per minute, at 50% duty cycle.

It is operated by a 36.3V, 2500mAh lithium-ion battery, with a run time of 30 minutes.

Users can select continuous, 30:2 or even 15:2 modes. In the latter two modes, there are two pauses of 1.5 seconds to allow a resuscitation breath to be applied.

For further information, see: www.zoll.com SC

MILITARY ROBOTS

The 2016 model of Boston Dynamics' "Atlas". It's what most people would expect a "robot" to look like but this is very much the exception!

Robots are increasingly being used in military applications where their most obvious advantage is the avoidance of danger to human soldiers. They can also do jobs that would be impossible for a human to do, such as tracking and shooting down an incoming supersonic missile.

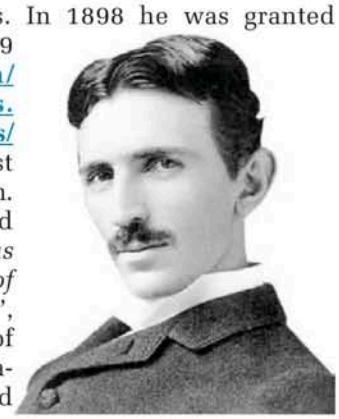
by DR DAVID MADDISON

Familiar examples of military robots, which may not be at first thought of as being robots, include remotely-operated tracked vehicles for destroying explosive devices, the autonomous Phalanx CIWS to destroy incoming missiles, cruise missiles such as the Tomahawk and surveillance and hunter-killer "drones" such as the surveillance Global Hawk and Heron (as used by the RAAF) and the armed MQ-1 Predator.

This list is expanding all the time and in this article we will discuss some past and present military robots and devices under development.

Nikola Tesla started it

Nikola Tesla laid the foundation for the first remotely operated machines. In 1898 he was granted U.S. Patent Number 613809 (https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US613809.pdf) for the first wireless remote control system.



The patent was entitled "*Method of and Apparatus for Controlling Mechanism of Moving Vessels or Vehicles*", and it covered "any type of vessel or vehicle which is capable of being propelled and

directed, such as a boat, a balloon, or a carriage."

He exhibited his "teleauto-mation" technology with a one-metre long battery-operated boat at an electrical industry trade show at Madison Square Garden where it was well received.

Tesla explained that he could easily build a larger boat, fill it with dynamite and steer it by remote control toward an enemy ship. Tesla also wrote that he could build a remotely controlled aircraft that "...could change its direction in flight, explode at will, and... never make a miss". In other words, he envisaged a flying bomb.

Tesla later went on to write in his book, "My Inventions" (1919), "*Teleautomats (robots as we now call them) will be ultimately produced, capable of acting as if possessed of their own intelligence, and their advent will create a revolution*".

In 1912, Tesla went into business with Jack Hammond to create radio-controlled torpedoes for the US Navy which were tested between 1914 and 1916 but the Navy did not pursue the idea.

The Hewitt-Sperry Automatic Airplane

The development of robotic remote controlled aircraft required three key technologies: 1) automatic stabilisation; 2) remote control via radio and 3) autonomous navigation.

In 1909, Elmer Sperry, famous for his work on gyroscopes, incorporated a gyroscope in a manned aircraft with a view to improving flight safety. The device performed poorly but it did coincidentally enable a way to provide stability for an unmanned aircraft. In 1911, he revisited the problem, encouraged by aviation pioneer Glenn Curtiss. He coupled a set of 3-axis gyros to a plane's flight controls via servo-motors.

In 1912, Curtiss tried to interest the US Military but after several crashes, the US Army were no longer interested. For their part, the US Navy was not interested because they thought the system was no substitute for a pilot. In 1914 Sperry's gyro-stabilised plane won a French prize but two weeks later war broke out and attention was diverted to other things.

Nikola Tesla tries to prevent WW2 and makes a prediction about the future of war

Tesla wrote this some time in the 1920s but it was not published at the time.

"At present, many of the ablest minds are trying to devise expedients for preventing a repetition of the awful conflict which is only theoretically ended and the duration and main issues of which I have correctly predicted in an article printed in the Sun of December 20, 1914.

The proposed League is not a remedy but, on the contrary, in the opinion of a number of competent men, may bring about results just the opposite. It is particularly regrettable that a punitive policy was adopted in framing the terms of peace, because a few years hence, it will be possible for nations to fight without armies, ships or guns, by weapons far more terrible, to the destructive action and range of which there is virtually no limit.

Any city, at a distance, whatsoever, from the enemy, can be destroyed by him and no power on earth can stop him from doing so.

If we want to avert an impending calamity and a state of things which may transform this globe into an inferno, we should push the development of flying machines and wireless transmission of energy without an instant's delay and with all the power and resources of the nation."

The Curtiss-Sperry Aerial Torpedo, demonstrated in 1916.

In 1915, Peter Hewitt saw potential in Sperry's invention to fulfil Tesla's 1898 concept of a flying bomb and wanted to co-develop such a device with him. However, they ran out of money until they received funding from the US Navy to develop an "aerial torpedo".

The guidance system for this aerial torpedo was demonstrated in 1916 where a manned aircraft was flown automatically over a set distance and then commanded to dive as would be required for the aerial torpedo. The pilot then took over the controls, recovered from the dive and returned to base. This aircraft was based on the Curtiss N-9 seaplane and became known as the Hewitt-Sperry Automatic Airplane. It was not accurate enough to hit a ship at sea but in 1917 the US Navy recommended its continued development.

There were two strands to the aerial torpedo program. One was to develop an autonomous version that would fly a predetermined distance and then dive onto the target. The other was to remotely control an aerial torpedo from another aircraft. The US Navy wanted to use the aerial torpedoes against German U-boats, U-boat bases and factories from distances of up to 160km. By November 1917 distances of 48km were being achieved with an accuracy of 3km, not exactly precision guidance by today's standards but impressive for the time.

Essential to the radio control of the aerial torpedo was the Audion vacuum tube which was the first triode device. It was able to efficiently amplify a radio signal, unlike previous devices. A version of the Audion was developed for the radio control equipment in parallel with the aerial torpedo. The wireless radio control system was patented and the patent can be viewed at **https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US1792937.pdf** "*Wireless-Controlled Aerial Torpedo*".

The Curtiss-Sperry Flying Bomb

It then became clear that the Curtiss N-9 seaplane was not an efficient enough platform. An order for six different specialised airframes for the aerial torpedo was made in October 1917 and it became the first purpose-built unmanned

The Soviet Reno-russky shown in Red Square.

aircraft, to be known as the Curtiss-Sperry Flying Bomb.

With an empty weight of 227kg, it could carry an explosive payload of 454kg and had a range of 80km, at a top speed of 145km/h. With the war coming to its end and with some technical issues with the airframes and other test failures, the US Navy discontinued work with Sperry and Hewitt.

Instead, it engaged other companies to develop airframes and autopilots and shifted emphasis on remotely operated or autonomous aircraft away from aerial torpedoes to their potential use as target drones.

Nevertheless, the Curtiss-Sperry Flying Bomb goes down in history as the world's first cruise missile.

The Russian Teletank

In 1927 the Soviet Central Laboratory of Wire Communication developed radio control equipment for a tank. This equipment was installed in a French Renault FT light tank design (otherwise known as the FT-17), nicknamed the "Reno-russky".

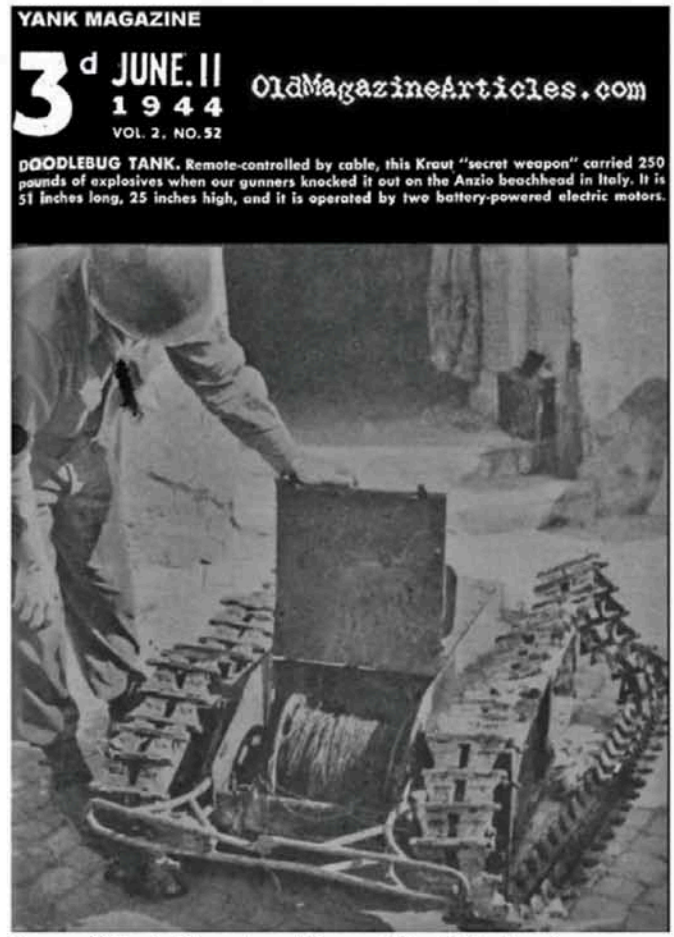
Military robots in World War 2

Military robots were first used in anger more than 70 years ago, in World War 2. The Soviets used the Teletank, the Nazis used the Goliath tracked mine and the Americans developed a bomber into a remote-control precision guided munition under the auspices of Project Aphrodite and they also developed an "attack drone" known as the TDR-1.

The Teletank design used by the Soviets in World War 2 were based on one of several designs and operated via wireless remote control from a manned tank at range of 500-1500 metres. The remotely operated tanks had the designation TT and the control tanks TU.

Apart from Soviet designs based on the French Renault

TU-26 control tank (left) with paired TT-26 Teletank (right) n the Ukraine in 1941. A total of 162 TU-26 and TT-26 tanks were manufactured.



Cover of Yank Magazine of June 11th, 1944 showing a Goliath found by GIs. The GI nick-name for the vehicle was the Doodlebug – a colloquial name more commonly used by Londoners for the V1 flying bombs (see elsewhere in this feature).

FT, there were others based on the British Vickers 6-Ton Tank, the French AMR 33 and a design based on the suspension developed by American J. Walter Christie.

Teletanks were equipped with a variety of weapons and could also deliver a large explosive charge of up to 700kg near enemy fortifications in order to destroy them. Teletanks could be controlled by between 16 and 24 commands, depending on the model and two radio frequencies could be used; the second frequency was selected if the first frequency was jammed.

For recollections of a Teletank operator of WW2 along with some technical information about the radio control mechanism you may wish to look at the blog post at **www.armchairgeneral.com/forums/showthread.php?t=132961**

The Goliath tracked mine

The Goliath tracked mine (known to the Allies as the Beetle Tank) was a small control-cable operated robot used by the Nazis in WW2. It was designed for general demolition and disruption work and could carry 60 or 100kg of explosives, depending on the model.

It was joystick-operated via a 3-strand, 650m long cable with two wires used for steering and forward motion and the third wire used to detonate the explosives.

Earlier models had electric motors and later models had a more reliable petrol motor. Its weight was 370kg for the

Goliath tracked mine of WW2 Germany at Vadim Zadorozhny's Vehicle Museum in Arkhangelskoye, the largest private collection of vehicles in Russia. Note motorcycles for size comparison. (http://tmuseum.ru/main-page)

electric model or 430kg for the petrol model.

Although over 7,500 of these devices were made, the Goliath was not considered a success. This was due to its high cost, complexity, vulnerability of its body and control cable, its slow speed of just 10km/h and inability to negotiate rough terrain.

Another disadvantage was that there was no way for the operator to get a view of the areas surrounding the vehicle.

A video of the Goliath can be seen at **https://youtu.be/zhK8L0PgPdA** "*Goliath Demolition Tank*".

Note that in this war-time video, they refer to one model as being radio-controlled although the control cable is shown and they also refer to a larger model that can drop off an explosive payload and return to base under radio control. This might well erroneously refer to the Soviet Teletank mentioned above.

Operation Aphrodite

Operation Aphrodite was an American program of late WW2 to take out hardened German super-gun sites, U-boat and V-weapons sites. The idea was to take B-17 and B-24 bombers that were beyond useful service life, strip out as much as possible to save weight (about 5400kg of equipment was removed), add remote controls, fill them with explosives and fly them to their targets.

The aircraft was loaded with around 9000kg of British Torpex explosives which were 50% more powerful than TNT. It was hoped that this program would give the US a capability that the British had with their Tallboy and Grand Slam ground penetrating bombs.

The remote controls consisted of radio control from a chase plane and two television cameras, one to look at the flight gauges and another to look ahead to be viewed by the controlling pilot. The television signal was transmitted to the chase plane.

The remote controls were not sophisticated enough to perform a take-off, so volunteer pilots flew them until they were in stable flight at 10,000ft and then parachuted out. The volunteers received a battle credit of five missions for this one take off, plus a Distinguished Flying Cross.

The program was a failure and none of the 14 missions flown resulted in any intended target being destroyed. There were many pilot deaths, one of which was Joseph Kennedy Junior whose aircraft exploded in mid-air before he and his colleagues had time to parachute out. A junior electronics officer had tried to warn about a wiring fault the previous day but was not listened to and it is likely that this defect cause the premature explosion.

For some video of Operation Aphrodite see **http://channel.nationalgeographic.com/the-strange-truth/videos/WW2s-operation-aphrodite/** "*WW2'S OPERATION APHRODITE*" and **https://youtu.be/BTiblDZhAOg** "*Operation Aphrodite 1940s Remote Control Airplane as Bomb*".

TDR-1 assault drone

The TDR was an unmanned, radio controlled "assault drone" developed during WW2 for the US Navy.

The idea for a remotely piloted aircraft for Naval combat operations had been proposed as early as 1936 but it wasn't until the development of the radar altimeter and television that this project became feasible.

The TDR first flew in 1942, was introduced in September 1944 and was retired from service in October 1944. Only 200 of 2000 ordered units were built.

It was designed to carry bombs or torpedoes and was controlled via a radio and television link from a chase aircraft. For testing purposes, the vehicle could be piloted but for normal operation the cockpit canopy was removed, improving its aerodynamic properties.

In order to minimise consumption of strategic war materials the frame was fabricated in tubular steel by the Schwinn bicycle company and it had a moulded wood skin.

A total of 50 drones were flown in combat, 37 of which reached their targets.

There were some problems with the aircraft which, combined with the success of conventional warfare operations, meant that this project was not regarded as a great success.

For a video of test footage of the TDR-1 see **https://youtu.be/CwS669Ipgwc** "*U.S. NAVY WW2 TDR-1 DRONE OPERATIONAL TESTS IN SOUTH PACIFIC 30772*".

German V1 "Doodlebug"/"Buzz bomb" and V2

Another early "drone"-type aircraft was the German V1. It was a rudimentary cruise missile. It looked like a plane

A robot kills a domestic terrorist

Over 2000 terrorists have been killed by US military aerial drones but recently in the US for the first time a domestic terrorist was deliberately killed by a robot. The terrorist killed five police officers in Dallas, Texas on June 7th, 2016 and would not give himself up so police judged that the only way to neutralise him was to deliver an explosive charge, normally used to detonate bombs, to his location.

The robot used was the Andros Mark V-A1 made by Northrop Grumman and was used to deliver about 450g of C-4 detonation cord to the target. Note that the robot did not operate autonomously; it was radio-controlled. It has not been stated whether the robot was damaged in the incident.

For a (silent) video of this model of robot in operation see **https://youtu.be/w7W3Kd9Cr-s** "Remotec Andros Mark 5A-1- Bloomington Mn Bomb Squad July 3, 2012 ".

Snake Robot in its natural habitat. Note how the robot has its body raised to get a better view with the head mounted camera.

The MAARS Robot is equipped with a quad tube 40mm grenade launcher which can be loaded with lethal or non-lethal ammunition, along with a medium machine gun.

and was powered by a pulse-jet engine that run on petrol and was stabilised by a gyroscope.

Essentially, it was pointed in the direction of the target (often London) and launched off a ramp. It would then fly to the target, dive and explode on impact. The location to dive was determined by measuring the flight distance with an impeller. The first of over 10,000 was launched in June 1944. At times, more than 100 hit London in a single hour.

While not normally considered a "robot", its successor, the V2 ballistic missile, was also autonomous after launch. In fact, modern ballistic missiles perform quite complex tasks autonomously including mid-course corrections, separation of multiple warheads with independent targeting and even deploying countermeasures such as chaff and flares designed to confound attempts to intercept the warhead(s).

Later Soviet Teletanks

In 1966 the Soviets developed the T55-based Teletank which was called the VNII-100. A video of it can be seen at **http://shvachko.net/teller/wp-content/uploads/2012/03/Teletank_T-55.mp4**

In 2000 a robotic T-72B tank was developed and it can be seen at **http://shvachko.net/teller/wp-content/uploads/2012/03/Teletank_T-72B.mp4** The videos are narrated in Russian but are still informative to watch.

Current military robots

Military robots can usually be loosely categorised by to their function, such as surveillance, troop assist, self defence, attack, area patrol, hazard disposal, obstacle clearance or search and rescue. Sometimes military robots fall into more than one of these categories, as the following examples will show.

Snake Robot

While the present developmental status of this system is unknown, in 2009 Israel demonstrated a 2m long robotic snake that could crawl through long grass and raise its head when necessary, crawl over or under obstructions and crawl into pipes. Designed by Technion, it is equipped with a camera and microphone and is controlled via a laptop.

The snake is capable of being equipped with explosives so it could slither up to an enemy position and detonate. Another possible use for this robot is to crawl into collapsed buildings (due to an earthquake, for example) to look for survivors.

This snake robot provided the inspiration for a 2013 medical robot for keyhole surgery known as the Flex Robotic System.

For a video of the snake in action see **https://youtu.be/1JnQL7mjspg** *"Israeli Military Testing 'robotic' Snake"*.

Surveillance and attack

The Modular Advanced Armed Robotic System (MAARS) produced by QinetiQ in the USA is a tracked unmanned ground vehicle (UGV) "designed expressly for reconnaissance, surveillance, and target acquisition (RSTA) missions".

The robot can operate at up to 1km from the operator and its sensors incorporate multiple on-board day and night cameras, motion detectors, an acoustic microphone and a hostile fire detection system. It can also provide warnings to an enemy via a loudspeaker system or a siren.

The device can carry a variety of payloads from non-lethal to "less than lethal" or lethal, as follows:

Non-Lethal – Audio deterrent (operator's voice through on-board loudspeakers), pre-recorded messages, siren, eye-safe lasers to disorient and confuse.

Less-Lethal – 40mm grenade launcher with the following grenade capabilities: sponge round, buckshot, tear gas, smoke or flare/illumination rounds.

Lethal – 40mm grenade launcher with the following grenade capabilities: high explosive (HE), high explosive dual purpose (HEDP), high explosive air burst, M240B medium machine gun with 450 rounds of 7.62mm ammunition.

The robot can also tow cargo such as a slide (as per the video) or trailer carrying an injured soldier or other equipment. It has a battery life of 3 to 12 hours or can be put in a sleep mode for up to a week. A human is required "in the loop" to operate any weapons system.

For a video of MAARS in action, see **https://youtu.be/bczvYHcSu98** *"MAARS Modular Advanced Armed Robotic System"*.

PackBot

The PackBot 510 by iRobot (the same company that makes the Roomba robotic vacuum cleaner!), is one of

The Packbot 510, one of the most widely-used military robots in the world with over 4500 in service.

the most widely used military robots in the world. It is a tracked robot with a wide variety of options to enable it to be used for missions such as bomb disposal, including roadside IEDs, surveillance and reconnaissance, searching of buildings, caves and tunnels etc.

Over 4500 Packbot 510s are in use worldwide. The robot is controlled via a game-style hand controller. To overcome limitations of line-of-sight communications, it can also employ an optional mesh radio kit with multiple nodes to relay communications.

Other features include an ability to retrace its steps and return to base if communications are lost. It can right itself if flipped over, can maintain a set heading and make adjustments for going over debris etc. On one battery charge it can travel around 16km in four hours.

Among numerous optional accessories are an "Enhanced Awareness Payload" which includes a wide-angle video camera, different manipulator arms, an explosives detection kit, thermal camera, HazMat detection kit, route clearance kit and cable cutters.

This robot is battle-proven with 2000 having been used by coalition forces in Iraq and Afghanistan. They were also used to inspect the Fukushima nuclear plant.

Missile defence robots

The Phalanx CIWS (close in weapons system), an autonomous military robot, is designed to shoot down incoming anti-ship missiles and defeat small surface vessels from a ship by firing 20mm projectiles from a six-barrel gun at a rate of 4500 rounds per minute at a muzzle velocity of 1100 metres per second.

It is possibly the only example in current use of a fully autonomous military robot because once it is armed, all of its functions are fully automatic. There are also lessons to be learned in respect of its autonomy, as illustrated by the following incident.

In 1989, during a US Navy exercise off the East Coast of the US, the Phalanx system successfully engaged a target drone and destroyed it but as the debris was falling to the ocean the Phalanx interpreted the falling debris as a threat and re-acquired it as a new target. As the debris fell close to the surface of the ocean rounds from the Phalanx were still being fired on the "target" and struck a ship behind the target, killing one officer and injuring another.

The Phalanx CIWS (Close In Weapons System) looks a little like R2D2 from Star Wars and is regarded by some people as a lethal autonomous weapons system (see box).

Presumably the software has been upgraded to avoid such incidents, as the software and hardware are under continual improvement.

See **https://youtu.be/Zdp9llrBLnA** "*Raytheon - Phalanx Close-In Weapon System (CIWS) & SeaRAM Anti-Ship Missile Defense System [480p]*".

A more recent development of CIWS is the Centurion C-RAM, which stands for "counter-rocket, artillery and mortar". It is a land-based version of the Phalanx which operates autonomously to defend a base against artillery attack.

In use since 2005, the Centurion is mounted on a trailer with a generator for power and uses its radar to detect and track incoming projectiles and attempts to destroy them before they land. It operates autonomously and uses self-destructing ammunition to avoid damage or injuries when rounds that miss their target fall back to Earth. The Centurion system defeated over 100 attacks on US bases in Iraq.

More recently, Israel have fielded the "Iron Dome" anti-rocket system which uses guided missiles to destroy incoming rockets. As such, it can engage larger targets at longer ranges over a wider area however the missiles are significantly more expensive than ammunition for the Centurion. Iron Dome also operates largely autonomously, since the time between the detection of an incoming rocket and its impact is typically measured in seconds.

Rheinmetall of Germany produce an automated base

Centurion C-RAM is a land-based version of Phalanx, used for automated base defence against artillery.

MANTIS C-RAM provides autonomous base defence and has been used by Germany since 2010.

The G-NIUS Guardium is a fully autonomous vehicle which can patrol a route, detect and fight off intruders.

defense system known as MANTIS Skyshield C-RAM, consisting of up to six automated turrets and two radar systems.

IAI Katana unmanned surface vessel

The Israel Aerospace Industries Katana is an unmanned (or optionally manned) surface vessel designed for homeland security and naval applications. It is controlled from a land-based mobile station or one on a mother ship.

The purpose of Katana is to patrol shallow coastal and territorial waters, engage in surface warfare and electronic warfare, provide harbour security and security around offshore oil and gas installations, to protect areas around undersea pipelines and to patrol a nation's offshore Exclusive Economic Zones as well as patrol for illegal immigrants or enemy combatants.

Katana is designed to avoid collisions and navigate and operate autonomously when required. It is capable of detecting, classifying, identifying and tracking a variety of targets. The system can be equipped with a variety of communication, electro-optical, radar and weapons systems and can also be operated via satellite so can work anywhere in the world.

The vessel is 12 metres long by 2.8 metres wide and has a top speed of 60 knots (110km/h) and is driven by two 418kW engines. Its range is 648km. It can be equipped with a variety of non-lethal or lethal weaponry. If desired, the Katana system can be retrofitted into an existing platform.

IAI Katana unmanned surface vessel, with its command and control station inset top right.

For a video of the Katana in action see **https://youtu.be/sOzBpOQNOIU** "*KATANA Unmanned Surface Vessel*". A similar vessel from Israel is from competitor Rafael and is called the Protector. See **https://youtu.be/hUPY5YZhT1Q** "*Rafael Protector USV*".

G-NIUS Guardium

The Guardium is a four-wheeled vehicle which can operate in fully-autonomous or semi-autonomous mode. It is equipped with sensors and can carry lethal or non-lethal weapons. It is already in use by Israel in the border-patrol role. Multiple vehicles are able to co-ordinate with each other. It has been in service since 2008.

Guardium is armoured to withstand attack and has several days' endurance for long-range missions. It can carry cameras, infrared cameras, radar, microphone and hostile fire detectors. The sensors allow it to patrol a pre-defined route while avoiding obstacles, surmounting difficult terrain and monitoring for intruders along the route.

BAE Systems Multi-Operated All-Terrain Vehicle (MOATV)

Soldiers have to often carry very heavy loads which limits their mobility and endurance. The MOATV is designed as a vehicle onto which soldiers can place their heavy packs and other loads in order to relieve them of that burden.

The MOATV can be operated in a number of modes such as simply following a soldier or group of soldiers as they walk along or it can be remotely operated or alternatively, it can be operated semi-autonomously whereby a target location is set and the robot navigates along roads or around obstacles. It could also be loaded with casualties which could be automatically returned to base for treatment.

A similar robot to this is the Lockheed Martin SMSS (Squad Mission Support System).

Who is the enemy?

Military robots can be either remote-controlled or semi-autonomous. Semi-autonomous robots are smart enough to determine which path to take but until now there has

Faception analysis of the Paris terrorist attacks. Traditional facial recognition software could detect three terrorists in a database. When the video surveillance of the attacks was analysed (using no prior knowledge) with Faception software it detected nine terrorists including two already in the facial recognition database and failed to classify two, one of which was in the database. Had the software been running live at the time it could have detected nine of the eleven terrorists.

been no way machines could distinguish the good guys from the bad guys.

Israeli company Faception (www.faception.com) has developed facial analysis software that can determine, without any prior knowledge of a person, whether or not they are a terrorist, for example. It does this based on facial characteristics alone and a suspect does not need to be in a database, ie, it is not just a matter of matching a face to an existing database entry.

Faception can work with still images or live video streams. Apart from being able to detect terrorists with a high level of accuracy, once the software has been trained it can classify faces according to any other number of descriptors such as extroverts, people with high IQs or "poker players" so apart from law enforcement, it has any number of other possible uses.

The theory of operation of this software is that personality traits are reflected in facial features. This connection was proven in a research paper that can be seen at www.researchgate.net/publication/44614706Internal_facial_features_are_signals_of_personality_and_health

Researchers Kramer and Ward showed in 2006 that four of the so-called Big Five personality traits were reflected in facial features. The Big Five personality traits are openness to experience, extroversion, agreeableness, neuroticism and conscientiousness (the one trait found not to be reflected in the face was conscientiousness).

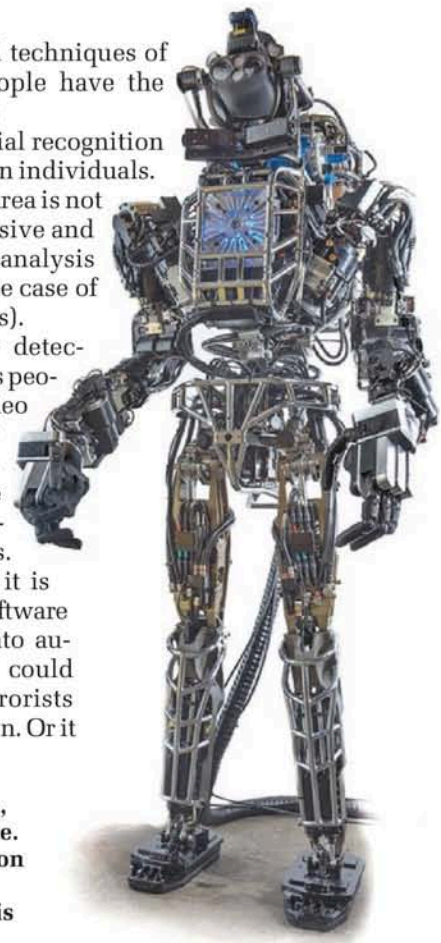
For centuries the Chinese have believed that a person's personality can be read from their face.

The main advantage of Faception is that it can detect a suspicious person based on only their facial appearance. In contrast, conventional techniques of detecting suspicious people have the following disadvantages:

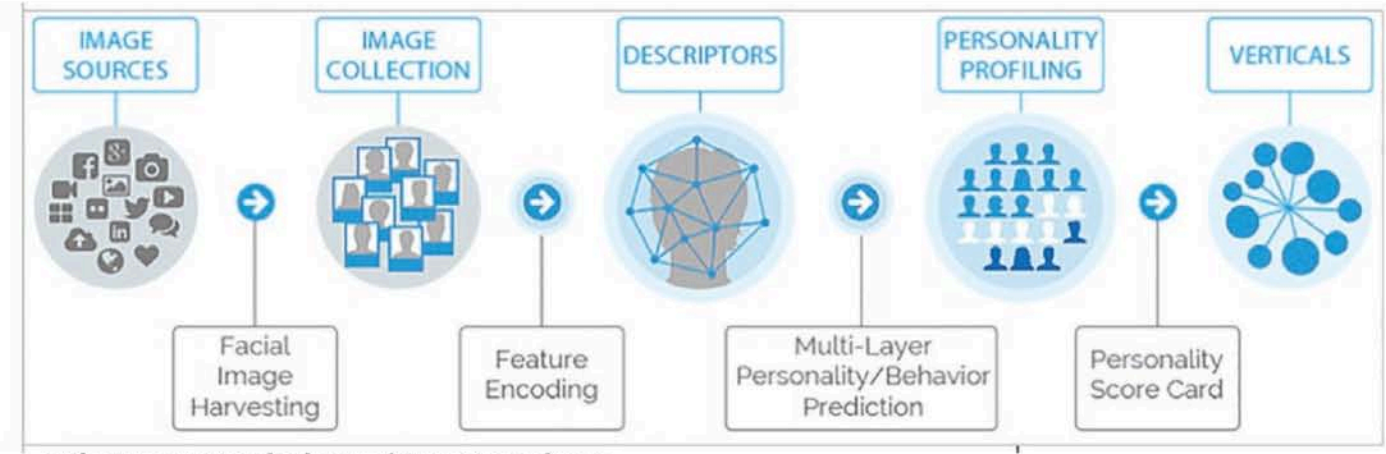
Fingerprinting and facial recognition are only suitable for known individuals. Video surveillance of an area is not focused and labour intensive and usually only useful for analysis after an incident (as in the case of the 7/7 London bombings).

Suspicious behaviour detection software that analyses people's movements from video feeds and detects if they have been loitering for an inappropriately long time can be tricked and "profiling" can be subject to bias.

Looking to the future, it is conceivable that this software could be incorporated into autonomous robots which could patrol areas, detect terrorists and take appropriate action. Or it



The early version of Atlas, complete with power cable. The later version (shown on page 22) runs on internal power and its "skeleton" is covered.



▲Above: operational scheme of Faception software.

Right: a comparison of the Faception ▶ software to traditional facial recognition software.

CHARACTERISTIC	FACE RECOGNITION BASED	FACEPTION Facial personality profiling
Objective	Identify or verify an individual (known)	Reveal an individual personality (anonymous)
Input	Facial image	Facial image
Prior knowledge required	Up-to-date facial image of individual	None
Technology used	Similarity-based search & match	Trait/behavior classifiers
Output	Degree of match to a known individual	Degree of match to a set of traits/behaviors
Action	Apprehend and detain	Increese attention level, search/investigate/follow

could be incorporated into personal robots that could interact more effectively with their owners by reading their faces.

For a video explaining how the software works, see **https://youtu.be/x1QsDiWCV-o** "*Faception pitch 2 min*".

Robots under development

We will now look at some novel robots currently under developments which are not simply more advanced versions of those machines or themes discussed above.

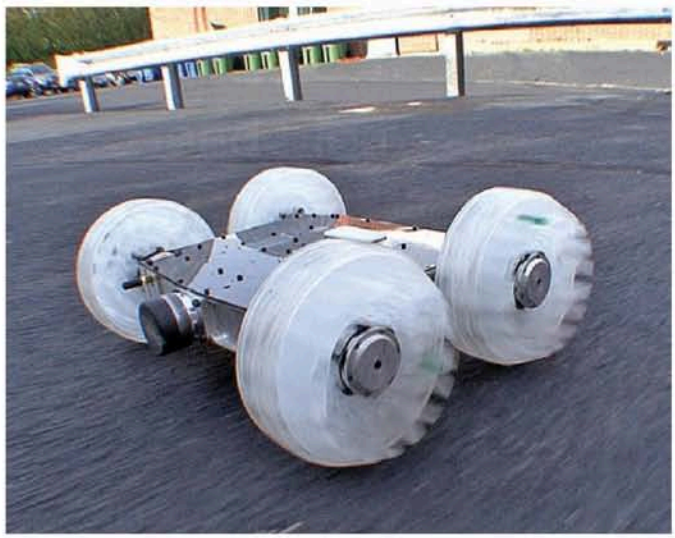
Boston Dynamics Atlas

Atlas is a bipedal humanoid robot developed by Boston Dynamics, a company now owned by Google. Atlas was first unveiled in 2013 but an improved version was released this year. The new version runs on internal power and has LIDAR and stereo video sensors to develop a 3D view of environment in order to autonomously navigate. Its movement is very human-like.

The primary role for this robot is to perform operations such as moving objects, turning on or off valves or opening doors in hazardous environments not suitable for humans. It is intended as an aid to emergency services and even though it is funded by the US Department of Defense, they have stated they do not intend to use it in combat operations although there is obvious potential there.

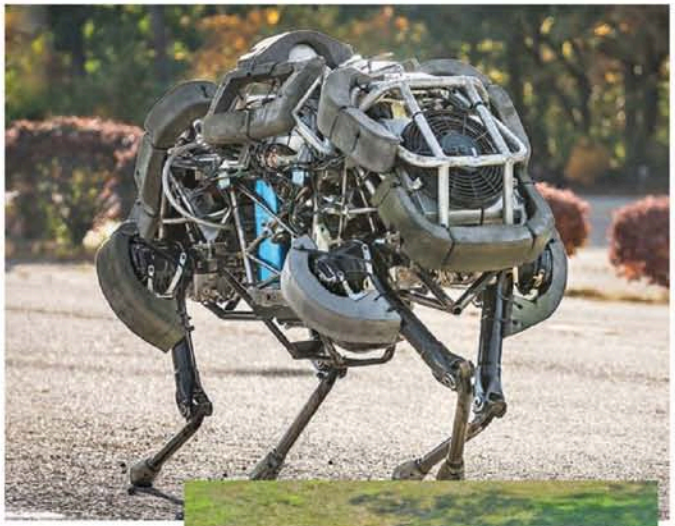
To fully appreciate the amazing capabilities of this robot it is best to watch the suggested videos.

The earlier version of Atlas can be seen here: **https://youtu.be/WYKgHa8hH1k** "*Boston Dynamics - Atlas Robot Rocky Terrain & Balancing Tests Update [720p]*".



Boston Dynamics Sand Flea, which can jump 8m.

Sand Flea in multiple exposure showing jumping action.



WildCat quadruped robot (above) and "galloping" across a field (right).

For a video of the latest version of Atlas in operation see https://youtu.be/rVlhMGQgDkY "*Atlas, The Next Generation*".

Boston Dynamics Sand Flea & Wild Cat

Sand Flea is a small wheeled robot with a camera which has one unique capability to jump as high as 8 metres in order to clear obstacles, jump onto roofs, up vertical embankments or through open windows.

During flight it is gyro-stabilised to keep it level. It weighs about 4.9kg.

It has batteries for drive and a gas cylinder to provide power for jumping which give an endurance of 2 hours and 25 jumps. It is being funded by the US Army. See the Sand Flea at https://youtu.be/6b4ZZQkcNEo "*Sand Flea Jumping Robot*".

WildCat is a free running quadruped robot that can run at up to 26km/h (powered by a very noisy 2-stroke motor!). Its purpose is to explore ways in which quadruped robots could be used by the military, especially to move supplies over rough terrain. One example would be to carry troop backpacks or other supplies.

BAE Systems Taranis, unmanned combat aircraft system advanced technology demonstrator.

Other reading

SILICON CHIP has previously looked at military robots:

"The Avalon 2013 Airshow" in the May 2013 edition. Robots covered included the Northrop Grumman MQ-4C Triton UAV and the Heron UAV as used by the RAAF.

"The Autonomous Ground Vehicle Competition" in the April 2014 edition, covering the Phalanx CIWS to destroy anti-ship missiles and the G-NIUS Guardium MKII Autonomous Ground Vehicle.

"The Australian International Airshow 2015" in the May 2015 edition. mentioning the MQ-8C unmanned helicopter, the MQ-4C Triton UAV, the Aersonde Mk4.7 UAV and AAI RQ-7B Shadow 200 UAV, the Silvertone Electronics Flamingo Mk1 UAV and the MQ-9 Reaper UAV.

Also see articles by Bob Young in July 1999, April, May & June 2001 and June 2010.

See WildCat at https://youtu.be/wE3fmFTtP9g "*Introducing WildCat*".

Boston Dynamics LS3

The LS3 (for Legged Squad Support System) is a system designed to assist troops by carrying up to 180kg of equipment. It reached a sufficiently high level of development that it was used by the US Marines in exercises.

It had a high level of reliability and if it fell over it could right itself most of the time but it was unable to traverse certain types of terrain. Another problem was that its motor was quite loud.

This robot, which cost US$42 million to develop, was not accepted into service but the potential remains for this type of robot to assist troops in the future.

You can see the LS3 at https://youtu.be/OYs0Rq66-U4 "*Boston Dynamics LS3 Military Robot Delivering Water to U.S. Marines*" and https://youtu.be/pZu-xWX4Buk "*LS3 Robot Patrols With Marines, Comes Under Simulated Mortar Attack*".

Mind you, these videos also show that these machines have a long way to go if they are to be really useful on the battlefield.

BAE Systems Taranis

The BAE Systems Taranis is an unmanned combat aerial vehicle that can search for, locate and identify enemy targets but at present requires a person to give permission to fire. It currently is not fully autonomous but could be made to be. It can also defend itself against attack.

(Incidentally, its first flight was at Woomera, SA in 2013).

It is designed for long-range intercontinental missions, can attack aerial or ground targets with a variety of weapons stored in two internal weapons bays, utilises stealth technology and is linked to a ground control station via satellite.

The aircraft is 12.4m long with a wing span of 10m and it has a maximum take off weight of about 8000kg.

Concluding remarks

Military robots are developing at a rapid rate and could provide the option of making warfare safer for the side employing them by removing soldiers from the most hazardous situations.

The overall trend is that the robots are becoming more autonomous and more lethal. SC

Not One . . . But Two (Your Choice!)

230VAC mains timers to build

Version 1 - Cyclic Timer for Pumps and Compressors

Version 2 - Period Timer to run an appliance for set time

Do you have a pump or compressor which runs cyclically? Then you don't want it to keep running if a pipe bursts, do you? To stop that happening, build the SILICON CHIP 230VAC Cyclic Pump Timer. Or perhaps you have an appliance which you want to run for a set time and then turn off. For that you need to build our 230VAC Period Timer. It can be set to run for any period up to 250 minutes and then it will turn off.

The initial impetus for these timer projects came from a reader's suggestion.

He had a pump which supplied water to his house on a farm. One day the pipe from the pump to the house burst and then the pump completely drained his rain-water tanks.

And coincidentally, he also had an air compressor which again had burst a hose so the compressor ran for the entire weekend!

In both of these situations, the result could have been even worse if the pump had failed from running dry or the compressor motor had burnt out because of overheating.

After all, most pumps and compressors are not usually rated for continuous operation. Both of these situations could have been avoided with a suitable timer.

Mind you, the total draining of water storage on a farm could also happen if a tap was inadvertently left on.

So that was how the Cyclic Pump Timer came to be designed. It monitors when power is being used and if it runs for more than the usual cycle, for example 10 minutes, its internal heavy duty relay will switch off the power.

When it switches off the power, it lights a red LED which tells you a fault condition has occurred.

You can restore operation by hitting the Reset button and then determine where the fault lies.

Features:

- *30A switching contacts*
- *Configurable as a safety timer or a standard timer*
- *Timer LED indicators*
- *Versatile timing range*
- *Draws minimal standby power (<0.17W)*

Version 2 – Period Timer

During the design process we realised that the proposed circuit had a wider application, as a general purpose timer, but without the current monitoring facility.

So that became version 2, a straight 230VAC Timer. This could be used for any device that you might turn on and then you might forget to turn it off after you used it. So it could run for many hours or even days which would be completely undesirable. Not only does it create a fire risk, it would also chew through power, costing you $$$.

With this Period Timer, you could set a reasonable time when you turn on a soldering iron, an electric iron or a battery charger etc, without its own cut-out.

We are sure you'll think of lots of other applications.

Both versions of the timer use the same PCBs and both are housed in a small diecast case with an IEC mains

By JOHN CLARKE

connector and fuse for the power input at one end and a 250VAC mains outlet at the other end of the box.

On the lid are two pushbutton switches, a knob to set the operating period and two or three LED indicators. Their functions vary in each version of the timer.

Time period

The 230VAC Cyclic Pump Timer's period can be varied from 1 to 100 minutes while the 230VAC Timer (for appliances) can be set from 2.5 to 250 minutes (a little over four hours).

Now let's have a look at the circuit which is shown in Fig.1 overleaf. This includes all the circuitry for version 1.

To build the simpler 230VAC Period Timer, you leave out all the components associated with the current transformer, in the green shaded section of the circuit and one of the LED indicators.

The circuit

So now we will discuss the full circuit which is controlled by a PIC12F675 microprocessor. For simplicity, we'll assume the timer is being used with a pump – compressor and any other cyclical device operation is identical.

All the 230VAC mains circuitry is shown on the righthand side of the circuit, highlighted in pink.

The mains supply comes in via an IEC male connector. The Active line from the 230VAC mains passes through the core of the current transformer (T1), effectively a single-turn primary, and then through the contacts of a 30A relay (RLY1). This in turn connects to the Active (A) terminal of the 3-pin mains output socket.

The secondary winding of current transformer T1 drives a bridge rectifier consisting of diodes D1 to D4. The rectified output is fed via a 1kΩ resistor to a 4.7V zener diode, which limits the maximum DC level, and is then filtered by a 10µF capacitor and connected to the AN0 input (pin 7) of the PIC12675F microprocessor.

If there is no current passing in the primary of transformer T1 (ie, the pump is not turned on), it produces no voltage at its secondary. But if the current exceeds 700mA (0.7A), the resulting voltage of about 1V, detected at pin 7 of IC1, tells the microprocessor that the pump has started running.

It then starts its timer function, having first read the voltage at the AN1 input, pin 6. This input monitors the wiper of potentiometer VR1 which is the timer control.

VR1 can be adjusted between 0V and 5V, giving a time of one to 100 minutes, as mentioned earlier.

With the pump running, green LED1 will be flashing to indicate the timer is functioning.

If the pump operates normally, the timer function will be stopped when the voltage at pin 7 drops to zero, indicating that pumping has stopped. LED1 will stop flashing and will be on continuously.

On the other hand, if the pump continues to run and exceeds the period set by potentiometer VR1, the GP4 out-

Specifications:

Input	230VAC 10A
Power consumption	Less than 0.17W with relay off, less than 1.33W with relay on
Time-out adjustment	1-100 minutes (Cyclic Pump Timer) or 2.5-250 minutes (Period Timer)
Cyclic Pump thresholds	Above 700mA AC (approximately 160W for a resistive load) for timer start, below 250mA AC for timer reset (around 60W)

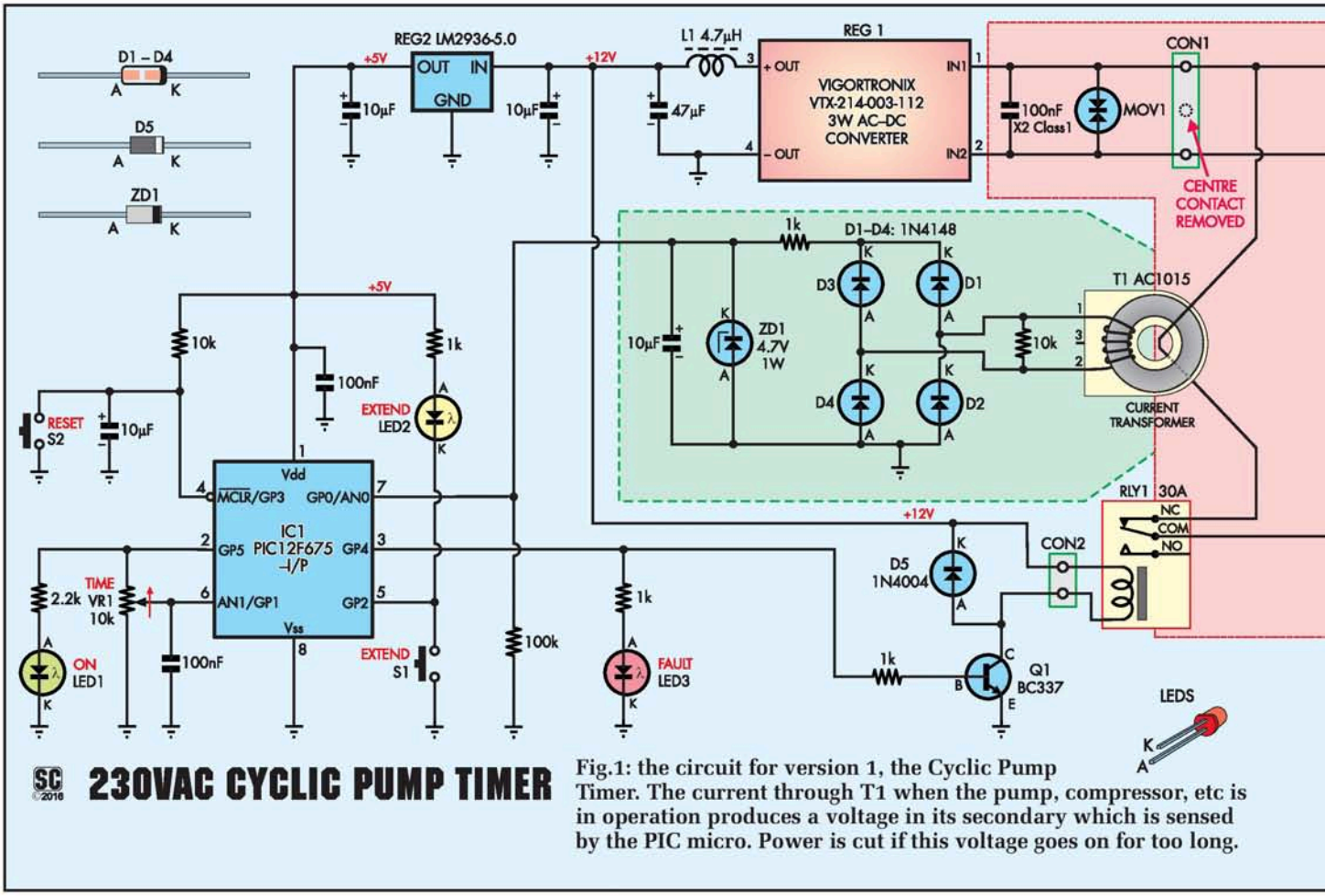


Fig.1: the circuit for version 1, the Cyclic Pump Timer. The current through T1 when the pump, compressor, etc is in operation produces a voltage in its secondary which is sensed by the PIC micro. Power is cut if this voltage goes on for too long.

230VAC CYCLIC PUMP TIMER

put, pin 3, goes high and switches NPN transistor Q1 on. This powers the coil of the 30A relay (RLY1) to disconnect mains power from the pump.

Red LED3, also connected to pin 3 of IC1 via a 1kΩ resistor will also light up, to indicate a fault condition. A 1N4004 diode (D5) is used to quench the back-EMF from the relay's coil when Q1 is switched off.

The timer is reset by pressing Reset switch S2. This pulls the $\overline{\text{MCLR}}$ input, at pin 4 of IC1, low to restart the program within IC1. $\overline{\text{MCLR}}$ is pulled high via a 10kΩ resistor while the 10µF capacitor between ground and the $\overline{\text{MCLR}}$ input ensures that IC1 is given a sufficient reset period. The capacitor keeps the input low for sufficient time for a device reset, even if S2 is only momentarily pressed.

Pushbutton S1 and yellow LED2 provides an EXTEND function. This is provided to allow a pump or compressor to run for much longer than the usual operating period when it is first turned on – to allow the system to come up to operating pressure.

When the pump finally turns off, LED2 will go out and then the timer is ready for the next on cycle of the pump (or compressor).

Power

Power for the timer circuit is provided by a Vigortronix switchmode module (REG1), which converts the incoming 230VAC into 12V DC output, to drive the 12V relay coil. Its 12V output is also fed to a 5V 3-terminal regulator (REG2) to power the microprocessor and the LEDs.

The incoming 230VAC supply connects to REG1 and a metal oxide Varistor (MOV1), the latter to suppress transients, in conjunction with a 100nF X2-rated capacitor which provides a degree of hash filtering.

REG1's 12V DC output is filtered with a 4.7µH inductor and 47µF capacitor.

We have used the switchmode module because it is cheaper than a conventional small mains transformer, bridge rectifier and capacitor supply and it is also very efficient. This approach results in a very low standby power of less than 0.15W.

As well, the 5V regulator draws a very low quiescent current, less than 15µA, and most of the time the microprocessor is in sleep mode if it is not providing a timing function.

Typically, IC1 wakes up every 2.3 seconds and checks for a DC voltage at its AN0 input, pin 7. If present, that indicates that the pump is running and timing function should be started.

Note that the contacts of the relay are wired so that 230VAC is connected via the current transformer to the mains output socket when the relay is not energised.

Specifically, we are using the NC (normally connected) and COMmon contacts. The relay is only energised if a fault condition is detected and that breaks the mains connection to the pump. Even then, the overall power consumption of the timer is only about 1.3W.

So that describes the circuit operation of the Cyclic Pump Timer. Now let's have a look at Fig.2 which is the circuit of the simpler 230VAC Timer.

It is similar to that of Fig.1 except that all the components associated with the current transformer (in the green

shaded section of Fig.1) are omitted.

This version of the circuit only has two LEDs, green LED1 and red LED2. The other important difference is the contact wiring of the relay. In this case, the relay is turned **on** during the selected time (as set by potentiometer VR1) and so the 230VAC passes via the NO (normally off) and COMmon contacts. So this means that when the relay is energised, the appliance connected to the mains output socket is powered and that only happens when the timer is started, by pressing switch S1.

When timing is in progress, LED2 flashes and the GP4 output of IC1, pin 3, is high to turn on transistor Q1 and the relay coil. At the end of the selected time period, Q1 is turned off to de-energise the relay and LED2 stops flashing. Of course, the timing period can also be terminated by pressing S2, the Stop button.

Note that both versions of the circuit, Fig.1 and Fig.2, use the same programmed microprocessor. It needs to detect which circuit it has been installed in and then it selects the correct software routine. How does it do this?

In both versions of the circuit, there is a 100kΩ resistor connected between pin 7 (AN0) and 0V but in the circuit of Fig.1, a 10µF capacitor is also present (as part of the current transformer circuitry).

Each time power is applied to the micro, it briefly pulls the AN0 pin high via an internal pullup resistor. After the pullup is switched off, 100 milliseconds later it measures the voltage at pin 7. If the voltage is above 200mV, that tells the micro that it is connected in the Cyclic Pump Timer circuit and it operates accordingly. On the other hand, if the voltage at pin 7 is very close to zero, that means that there is no 10µF capacitor present and the micro is in the circuit of Fig.2.

By taking this approach, we can use the same microprocessor for both versions of the Timer and there is no need for the constructor to make any program selection by means of links etc.

Other notes on the software

As already noted, IC1 is normally in sleep mode, during which it consumes minimal power. It wakes up each time its watchdog timer times out (every 2.3 seconds) or if switch S1 is closed. For the Cyclic Pump Timer, each time IC1 is woken by the watchdog timer, it

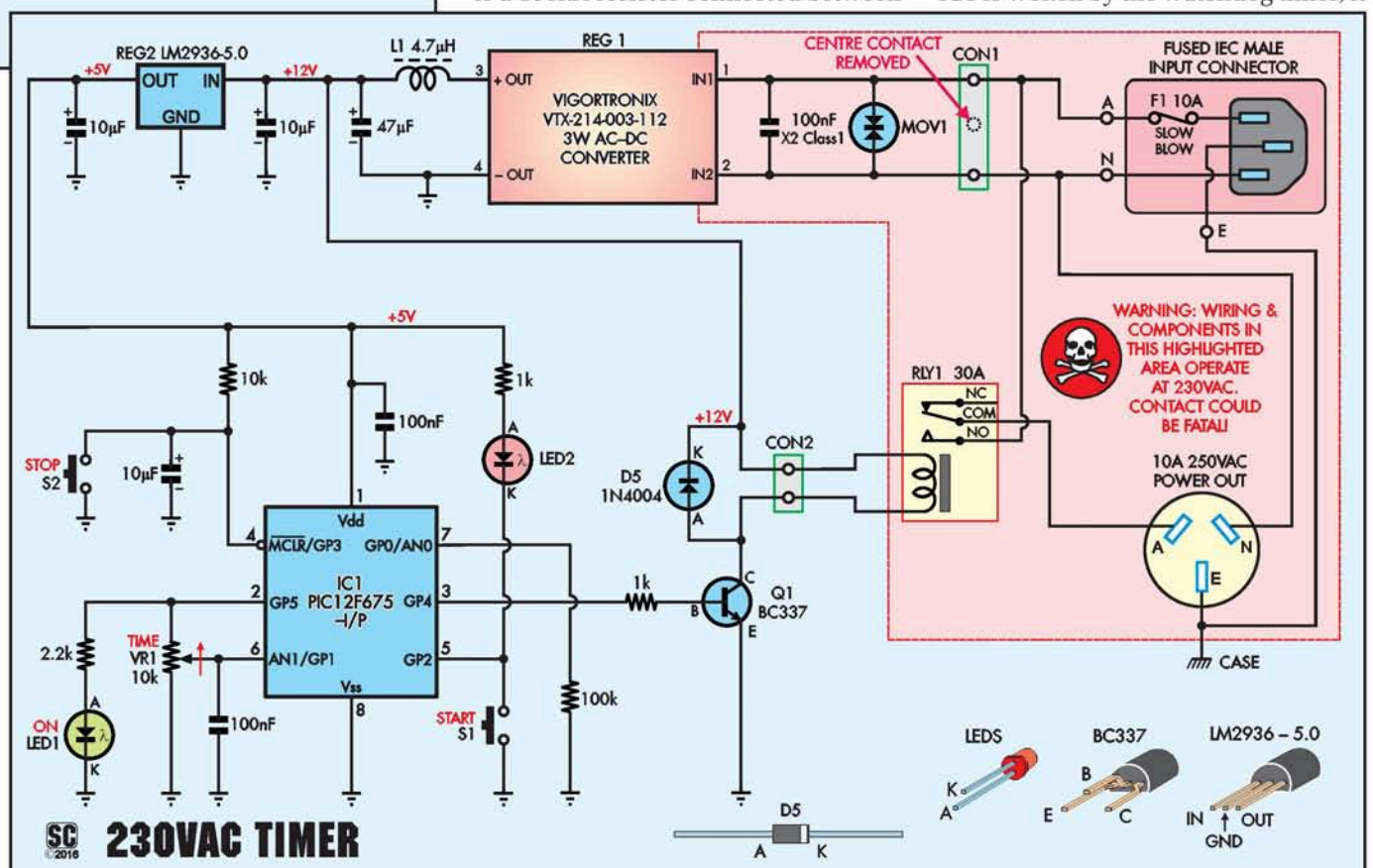


Fig.2: the general-purpose timer is simpler because it doesn't have the current-sensing circuitry. Power to the appliance is cut when a preset time is reached.

checks the AN0 input for a DC voltage above 200mV, as noted above.

Switch S1 is the Extend button for the Cyclic Pump Timer and the Start button for the straight 230VAC Timer. When S1 is pressed, this either wakes IC1 from sleep or if it is already awake, the GP2 input is changed to a low output that drives the indicator LED (LED2).

The software then checks if the GP2 pin is low, setting the extend feature for the Cyclic Pump Timer (or starting the 230VAC Timer). The GP2 output reverts to an input unless the LED is required to be driven independently of the switch being pressed.

Switch S2 is the Reset for the Cyclic Pump Timer and the stop button for the 230VAC Timer. This connects to the master clear ($\overline{\text{MCLR}}$) input of IC1. Pressing and releasing this switch causes the software to restart, clearing the timer.

Cycling timer assembly

Both versions of the Timer use two PCBs. One PCB is coded 10108161 and measures 85 x 78mm. The second is coded 10108162 and measures 83 x 35.5mm. The two PCBs are housed in a diecast box measuring 119 x 94 x 57mm and connected together with a short IDC cable.

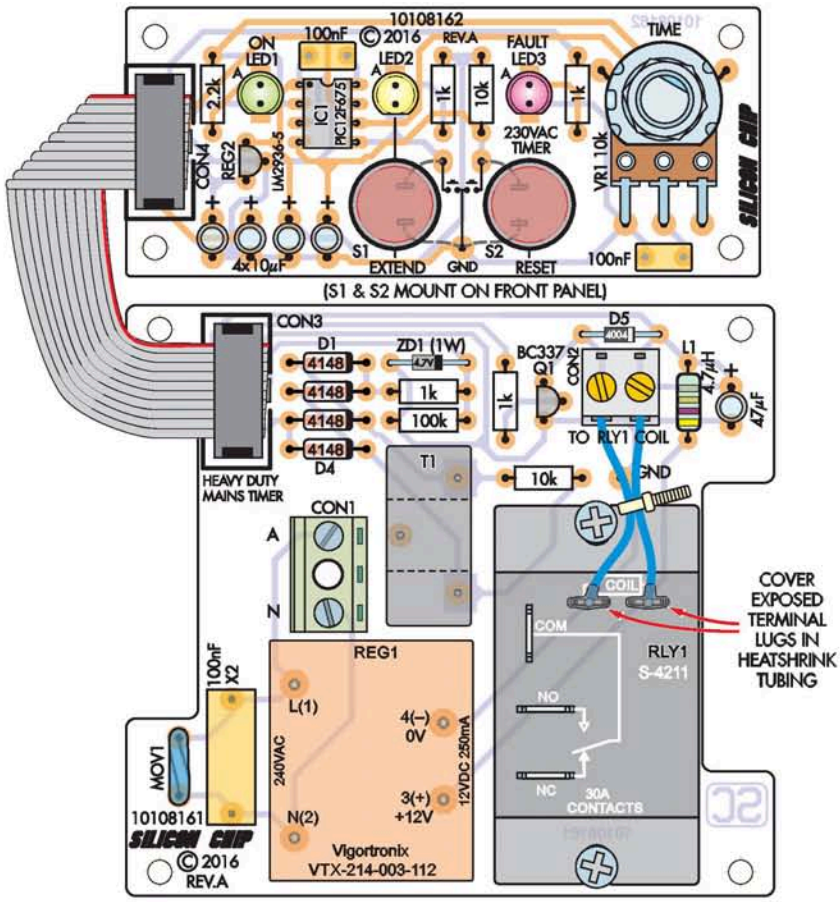
As already noted, the major difference between the two versions is that the current transformer and its associated components are only used in the Cyclic Pump Timer.

Fig.3 shows the two PCB overlays for the Cyclic Pump Timer. You can begin construction by installing the resistors on each PCB, using a multimeter to check the value of each one before inserting it on the PCB (and/or refer to the resistor colour code table).

Then install inductor L1, diodes D1 to D5 and ZD1 (if used). Note that D5 is a 1N4004 while D1-D4 are 1N4148s. The inductor looks like a fat resistor and has four colour bands: yellow (4), violet (7), gold (decimal point 0.1) and silver, signifying a 4.7µH inductor with a tolerance of ±10%.

REG2 on the smaller PCB and Q1 on the main PCB can be soldered in next. Don't get the regulators mixed up as they look similar, apart from their type markings. REG2 needs to be installed so the top of the package is no higher than 8.5mm above the PCB. A socket can be used with IC1 on the smaller PCB if you wish. Take care to orient each with the correct polarity.

We used PC stakes for the GND terminal on the main PCB, plus the connections to switches S1, S2 and potentiometer VR1 on the smaller board. Five PC stakes are used for VR1; three for the potentiometer terminal connections, one for the GND and the



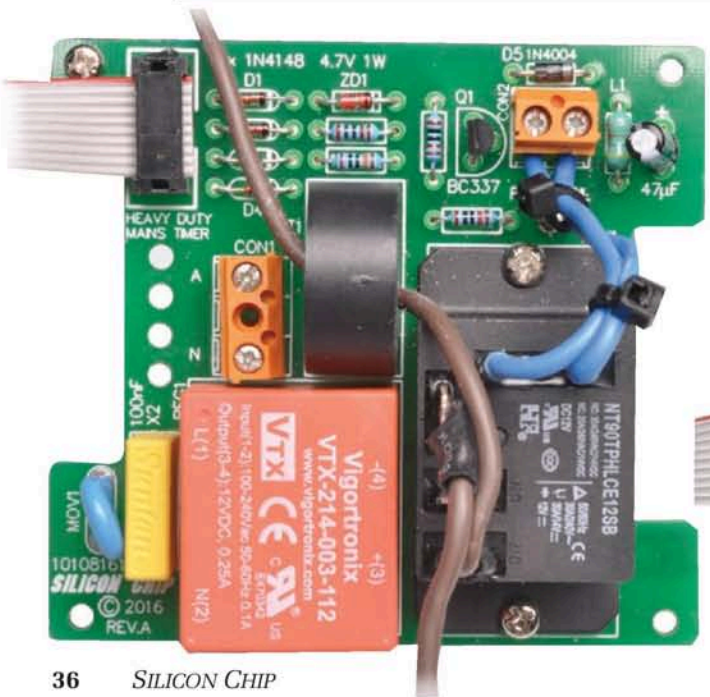
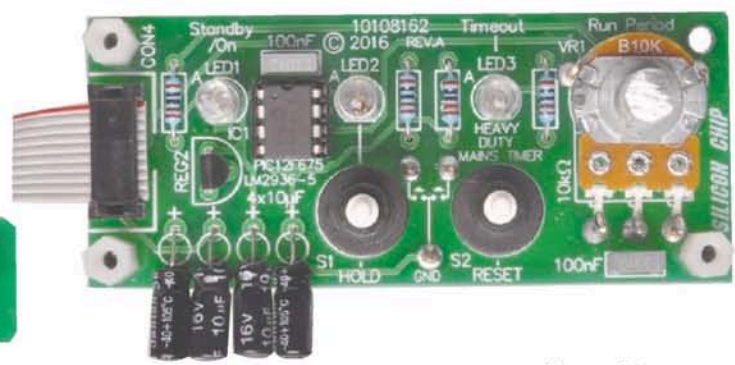


Fig.3 (above) shows the PCB layout for version 1, the Cyclic Timer. Match this with the photos below which are close to same size.



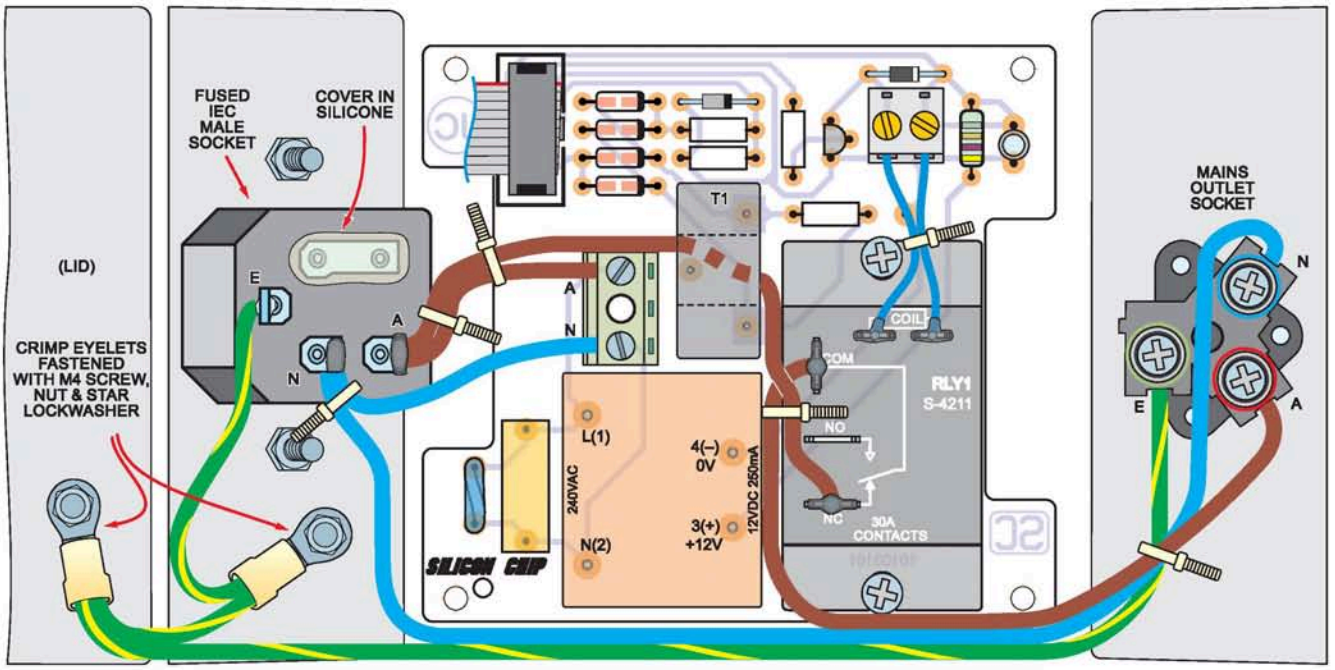


Fig.4: here's the wiring diagram for the Cyclic Timer (version 1). Remember that you are dealing with mains voltages so ensure that all cabling is fully secured with cable ties, as shown here.

remaining two for connection of the potentiometer body to the PCB. Cut the shaft of VR1 so that it is 10mm long (measured from the point where the shaft enters the threaded bush) and solder it to five PCB stakes.

To ensure a good connection to the potentiometer body, scrape any coating off the metal adjacent to where it will solder to the PC stake, then "tin" it with solder before actually soldering it in place.

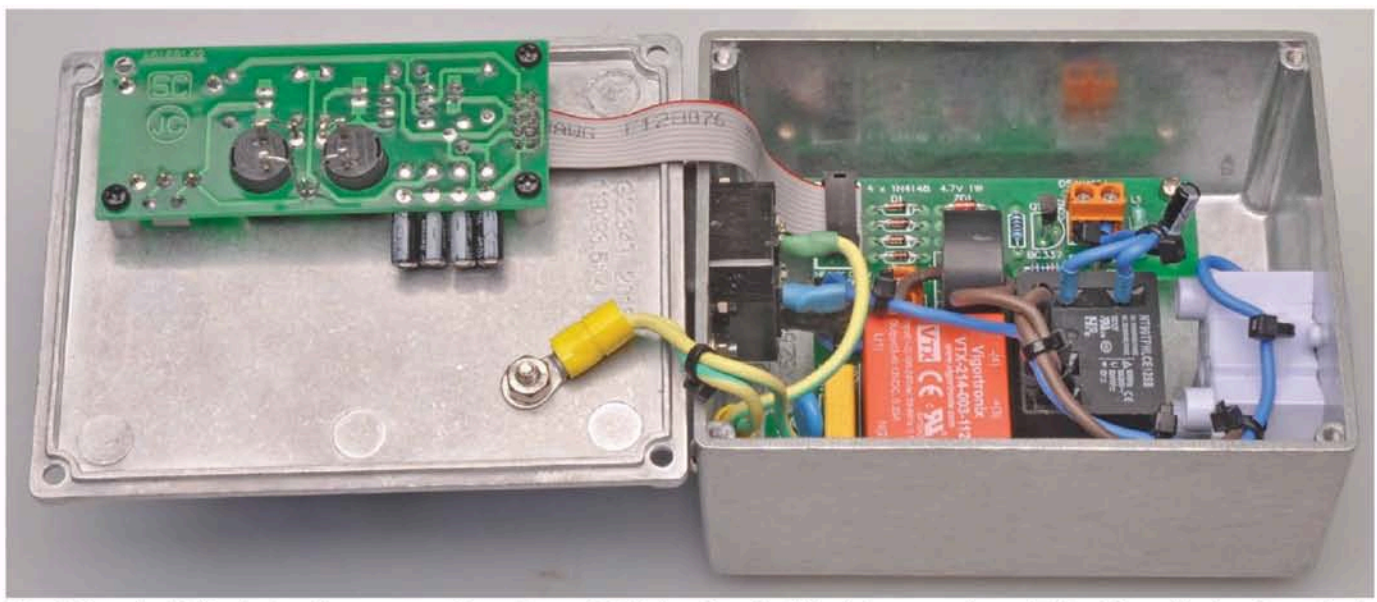
LED1 to LED3 are mounted so the tops of their lenses are 13mm above the top surface of the PCB. Make sure the longer lead of each LED (the anode) is inserted in the 'A' position on the PCB. LED1 is green, LED2 is yellow and LED3 is red.

You can check LED colour using the diode test on a multimeter. The LED should faintly glow when the probes are connected to the correct pins.

The four 10µF electrolytic capacitors are mounted so that they sit side-on and project out from the side of the PCB (see photo). This is so they don't foul the lid of the case when the PCB is mounted. Then install the two 100nF capacitors on the same PCB.

The 47µF electrolytic capacitor is installed on the main PCB next, again taking care with its polarity. Then fit the 100nF X2 class capacitor and MOV1. These are not polarised.

Next, install REG1, current transformer T1 and the terminal blocks, CON1 and CON2. Note that CON1 is a 3-way terminal block with the centre terminal removed (remove the screw and prise out the terminal with a fine screwdriver).



Here's how it all fits in the diecast case. Note the 2nd PCB fitted to the lid of the case via an IDC cable, with the electrolytic capacitors mounted parallel with the PCB so they can fit. Also note the earth lug firmly secured to the case lid.

Parts list – Cyclic 230VAC Timer

1 double-sided PCB coded 10108161, 85 x 78mm
1 double-sided PCB coded 10108162, 83 x 35.5mm
1 diecast box, 119 x 94 x 57mm (Jaycar HB-5064)
1 panel label, measuring 119 x 94mm
1 Australian/New Zealand standard mains socket with side wire entry (Altronics P 8241, Jaycar PS-4094)
1 IEC panel connector with fuse holder (Altronics P 8324, Jaycar PP-4004)
1 Australian/New Zealand standard 250VAC 10A mains plug to IEC socket lead
1 10A slow blow M205 fuse (F1)
1 30A SPDT 12V relay (Altronics S 4211) (RLY1)
1 4.7µH axial inductor (Altronics L 7018, Jaycar LF-1518) (L1)
1 10-way box header and matching IDC plug (Altronics P 5010 & P 5310) (CON3)
1 PCB-mounting 10-way IDC "transition plug" header (Altronics P 5160) (CON4)
1 Vigortronix VTX-214-003-112 12V 3W AC to DC converter (REG1) (element14 # 2401035)
1 AC1015 Talema 15A current transformer (T1: available from Silicon Chip www.siliconchip.com.au/Shop/7/3438) ***[not required for version 2]***
1 S14K275 MOV (Jaycar RN-3400, Altronics R 4408) (MOV1)
1 3-way screw terminal with 5.08mm spacing (CON1)
1 2-way screw terminal with 5.08mm spacing (CON2)
2 SPST momentary pushbutton switches (Altronics S 1405, Jaycar SP-0702) (S1,S2)
1 16mm 10kΩ linear pot with knob to suit (VR1)
1 DIL-8 IC socket
1 90mm length of 10-way ribbon cable
4 rubber feet
2 5.3mm crimp eyelets (yellow insulated)
7 M3 tapped x 9mm Nylon spacers
16 M3 x 6mm machine screws (or 7 M3 x 6mm countersunk screws and 9 M3 x 6mm machine screws) (for PCB and relay mounting)
2 M3 x 10mm countersunk or machine head screws (for IEC mounting)
2 M4 x 12mm countersunk or machine screws (securing earth eyelets)
4 M3 nuts
2 3mm inner diameter star washers (under IEC connector nuts)
2 M4 nuts with star washers
1 20mm length of 3mm diameter heatshrink tubing (relay coil terminals)
1 50mm length of 6mm diameter heatshrink tubing
1 250mm length of 10A three core mains cable (for Neutral blue wire, Active brown wire and Earth green/yellow wire)
1 60mm length of 0.7mm diameter tinned copper wire
9 PC stakes
7 100mm long cable ties

Semiconductors
1 PIC12F675-I/P programmed with 1010816A.hex (IC1)
1 LM2936-5.0 ultra-low quiescent current 5V regulator (REG2)
1 BC337 NPN transistor (Q1)
4 1N4148 diodes (D1-D4) ***[not required for version 2]***
1 1N4004 1A diode (D5)
1 4.7V 1W zener diode (ZD1) ***[not required for version 2]***
1 5mm high intensity green LED (LED1)
1 5mm high intensity yellow LED (LED2 in Fig.1)
1 5mm high intensity red LED (LED3 in Fig.1 or LED2 in Fig.2)

Capacitors
1 47µF 16V PC electrolytic
4 10µF 16V PC electrolytic [3 only for version 2]
2 100nF MKT polyester (63 or 100VDC)
1 100nF X2 class metallised polypropylene

Resistors (0.25W, 1%)
1 100kΩ 2 10kΩ ***[1 only for version 2]*** 1 2.2kΩ 4 1kΩ ***[3 only for version 2]***

The relay is mounted with the coil terminals toward CON2, using M3 x 10mm screws and M3 nuts. Wire the relay coil terminals to CON2 using 250VAC-rated wire. The terminals and soldered connections are then covered in heatshrink tubing with the two wires tied together with a cable tie.

The two PCBs are connected using a 90mm length of 10-way IDC cable, with an IDC connector at each end. Use the captive header for CON4 and the box header and plug for CON3. Feed the ribbon cable through the connector and clamp it down. The clamping can be done with a G clamp and suitable pieces of wood placed on top and bottom to protect the connector. See the overlay diagram as a guide to the correct wire orientation.

The next step is to drill the holes and make the cutouts in the diecast case and its lid. You will need to download the drilling template (it's free) for this task from our website at www.siliconchip.com.au

Make all the cutouts in the base of the case first and then then temporarily install the IEC connector and mains outlet socket. Then sit the main PCB in the box, positioned so it just clears the outlet. Mark out the four holes to mount the PCB on the base of the case and drill these at 3mm in diameter. Counter-bore the holes if using countersunk screws.

The main PCB is mounted on tapped 9mm Nylon spacers with M3 x 6mm screws to attach the spacers to the PCB and to the box.

Having drilled the lid of the case, three 9mm spacers are attached to the top side of the smaller PCB. Note that no spacer is used in the corner next to the potentiometer.

Instead, the PCB is retained by the nut on the potentiometer. Fit the potentiometer and switches with lockwashers and install all three, making sure they have the correct orientation for the switch terminals. Then fit the board to the lid and use tinned copper wire to connect the switch terminals to the three pads on the PCB.

Panel label

By the way, the front panel artwork is also available from the www.siliconchip.com.au website. Print off the label to suit the timer you are building.

To produce a front panel label, you have several options. One is to print

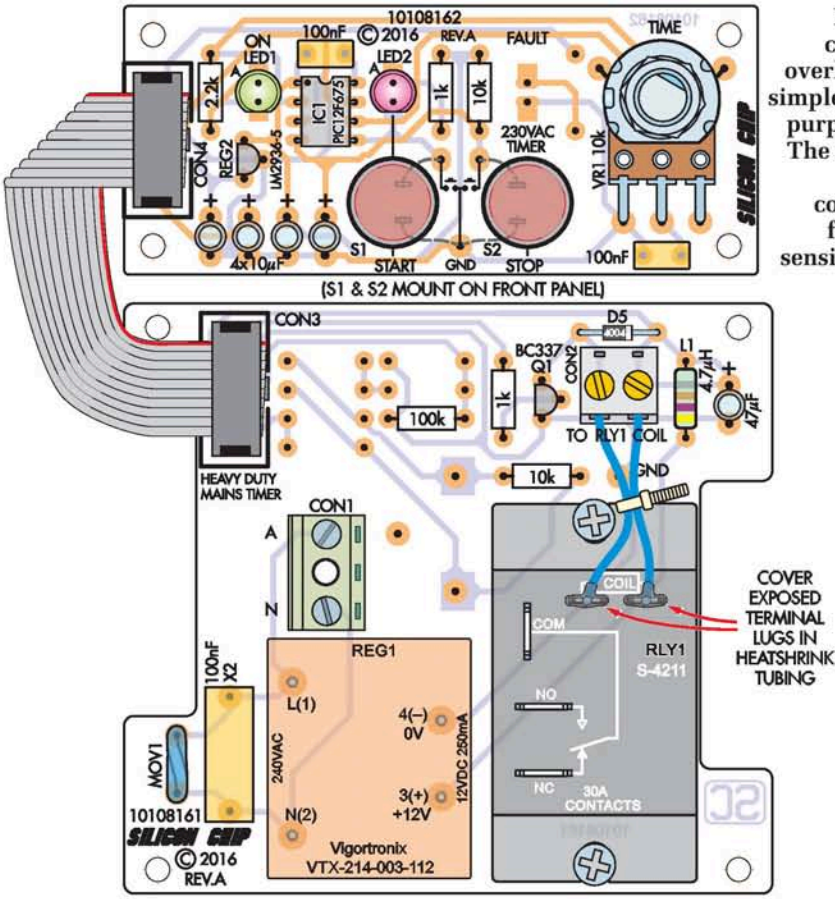


Fig.5: PCB component overlay for the simpler, general purpose timer. The difference is that components for current sensing are not required.

onto clear overhead projector film (using film suitable for your type of printer and as a mirror image so the printed side is protected against the lid). Attach to the lid with clear silicone sealant.

Alternatively, you can print onto an A4 sized synthetic 'Dataflex' sticky label that is suitable for inkjet printers or a 'Datapol' sticky label for laser printers. Then affix the label using the sticky adhesive back. Cut out the required holes with a hobby knife.

Completing the wiring

Follow the diagram of Fig.4 to complete the wiring. Use 250VAC 10A insulated hookup wire for the Active (brown), Neutral (blue) and Earth (green/yellow stripe) connections.

These wires can be obtained by stripping off the outer sheath of a short length of surplus 3-core 250VAC cord.

The wires are soldered to the terminals of the IEC connector, with the bare terminals covered in heatshrink tubing. When soldering, make sure the wires are first passed through the terminal hole and the wires bent back onto the terminal. Ensure the terminal and wire are heated sufficiently and

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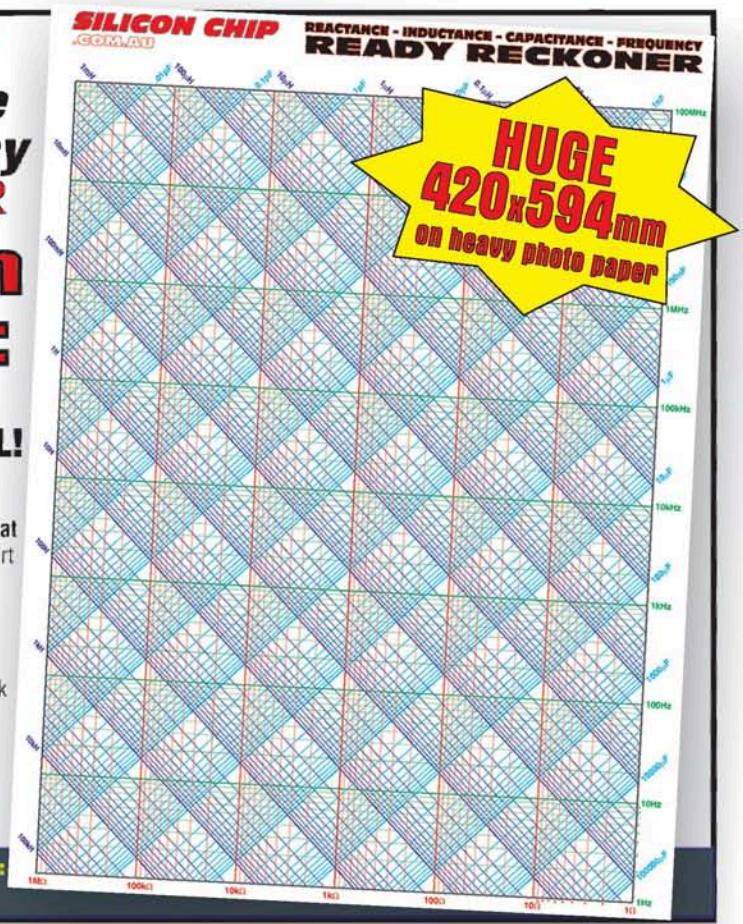

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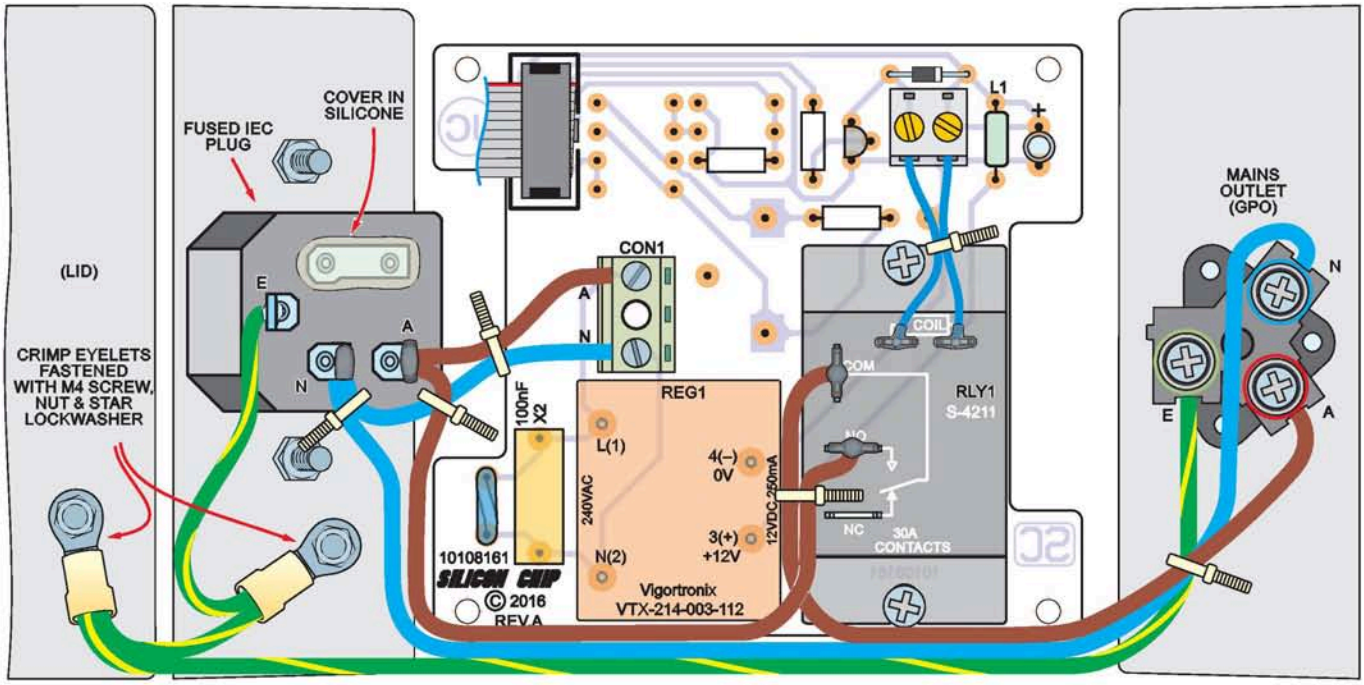

NOTE: COVER EXPOSED TERMINAL LUGS WITH HEATSHRINK TUBING

Fig.6: there are slight differences in this, the general-purpose timer and the cyclic timer shown earlier. Make sure you follow this diagram when building the general purpose timer.

that the solder flows onto the terminal and wire for a good joint.

The IEC connector is secured to the case using M3 screws, star washers and M3 nuts.

There are two wires used for the Active and Neutral connections with one set of Active and Neutral wires going to CON1. The second neutral wire connects to the mains socket and the active wire to a relay contact.

For version 1, this active wire must also pass through the current transformer.

Earth wiring is done using a continuous length of wire between the IEC connector Earth terminal and the mains outlet Earth. Insulation is pared back where this is to be terminated to the crimp eyelets. Use a crimping tool to clamp the wires into the eyelet crimp connection. You can solder the wire also to the eyelet to ensure it is firmly attached. Secure each eyelet to the case and lid using an M4 screw, star washer and M4 nut.

When finished, check your work carefully. Don't forget to install the fuse in the IEC connector. Screw on the lid and apply power.

No setting up is required as the microprocessor senses whether the current transformer components are installed (or not) and then uses the required program.

As noted in the specifications, the threshold current to start the timer function is 700mA AC. If you want to increase the sensitivity, loop the Active wire through the current transformer twice for a 350mA AC threshold, or three times for 233mA AC.

Note that all soldered terminals should be covered in heatshrink tubing. All other details can be noted from the internal photos.

Building the 230VAC Timer

If you're not building the Cyclic Pump Timer, use the PCB overlay diagram of Fig.5 and the wiring diagram of Fig.6 instead.

As already described, this simpler version of the Timer omits all the components associated with current transformer T1, with the exception of the 100kΩ resistor connected to pin 7 of IC1, plus LED3 and its 1kΩ resistor.

Note also the slightly different wiring of the contacts of the relay and its 1kΩ resistor. Finally, LED2 is red (not yellow). SC

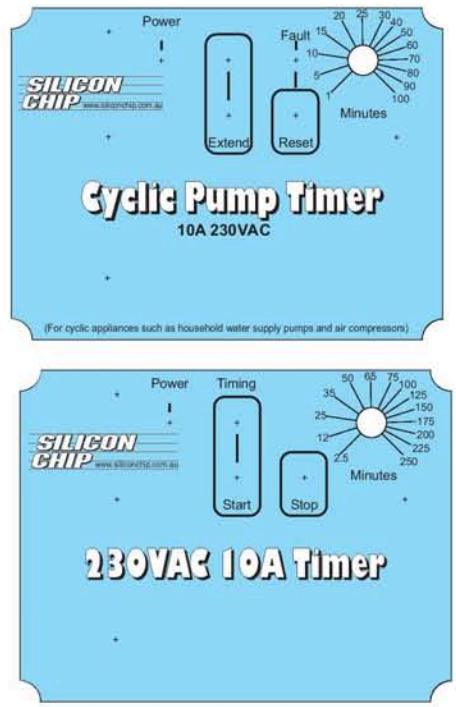

Fig.7: two different front panels are available, shown here half size. Artwork for these can be downloaded free of charge from siliconchip.com.au

Resistor Colour Codes

	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	100kΩ	brown black yellow brown	brown black black orange brown
❑	2	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	4*	1kΩ	brown black red brown	brown black black brown brown

* 2 required for version 2

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SPECIAL FEATURE:

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Electronex, Australia's only dedicated trade event for the electronics industry, returns to Sydney on 14–15 September at Australian Technology Park. With around 80 exhibitors, a technical conference and free seminars featuring leading international and local industry experts, this is an event not to be missed.

This year's expo continues to reflect the move towards niche and specialised manufacturing applications in the electronics sector and will also cater for the increasing demand from visitors for contract manufacturing solutions. There is expected to be a record number of exhibitors participating as the industry is seeing an upturn in demand from local manufacturers and specialist applications that are recognising the expertise and quality that is available from Australian-based suppliers.

The event targets design professionals; electronic and electrical engineers and technicians; along with OEM, scientific, IT and communications professionals and service technicians. Electronex was launched in 2010 to provide professionals across an array of industry sectors with the opportunity to learn about the latest technology developments for systems integration and production electronics. The last Sydney show in 2014 attracted over 1000 trade and industry visitors.

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The conference will include the following presentations (the complete conference and seminar program can be found on the show website):

Dr S Manian Ramkumar, Director – Center for Electronics Manufacturing and Assembly, Rochester Institute of Technology, will deliver three presentations: Defect Analysis and Process Troubleshooting; Characterising and Minimising Voids in QFN Device Assembly Using Lead Free Solder Alloys; and Root Cause Analysis for Reliability Issues in Electronics Packaging.

Dale Lee, Plexus Corporation, Staff DFX Process Engineer, will deliver two presentations: DFX Design for Excellence: DFM, DFA, DFT and More; and Flex PCB Design and Assembly.

Simon Blyth, Director of Engineering, LX Group, will deliver a presentation on the Internet of Things.

Dr Hamish Laird, ELMG Digital Power, will deliver a presentation on High Performance Digital Control.

Mark Steiner, Managing Director, Hetech, will deliver a presentation entitled To Design or not to Design a Commercial View to Product Development.

Details: When: 14–15 September 2016
Where: Australian Technology Park, Sydney
Website: www.electronex.com.au

ElectroneX
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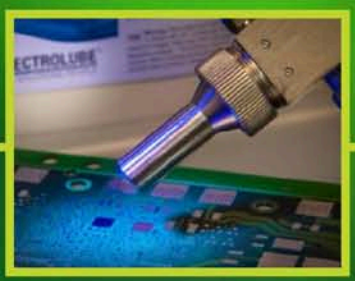

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Scope Rider and Spectrum Rider: new handheld test gear from Rohde & Schwarz

Rohde & Schwarz has recently released two matching handheld devices. First is the "Scope Rider", a handheld oscilloscope providing the performance and capabilities of laboratory oscilloscopes in a rugged and portable design, with a brilliant capacitive touch display and a remarkably easy-to-use UI. (See our review in the June 2016 issue . . . we were impressed)!

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It offers solid RF performance and high accuracy for measurements in the field and in the lab. Its large buttons and touchscreen make it very easy to operate. The instrument has a frequency range from 5kHz to 2GHz, which can be extended up to 4GHz with a key code.

The versatile R&S Spectrum Rider assists users during RF transmitter installation and maintenance and also supports measurement tasks in RF development labs and in service. With its high sensitivity of –160 dBm and measurement accuracy of typically 0.5 dB between 10MHz and 3GHz, the R&S Spectrum Rider offers class-leading RF performance.

The frequency range of the R&S Spectrum Rider can be extended via software upgrades, a feature unrivaled in this instrument class. The base model covers the frequency range from 5kHz to 2GHz, which can be expanded to 3GHz or 4GHz to support applications that require higher frequencies such as measuring radio signals above 2GHz or signals above 3 GHz in TDLTE bands.

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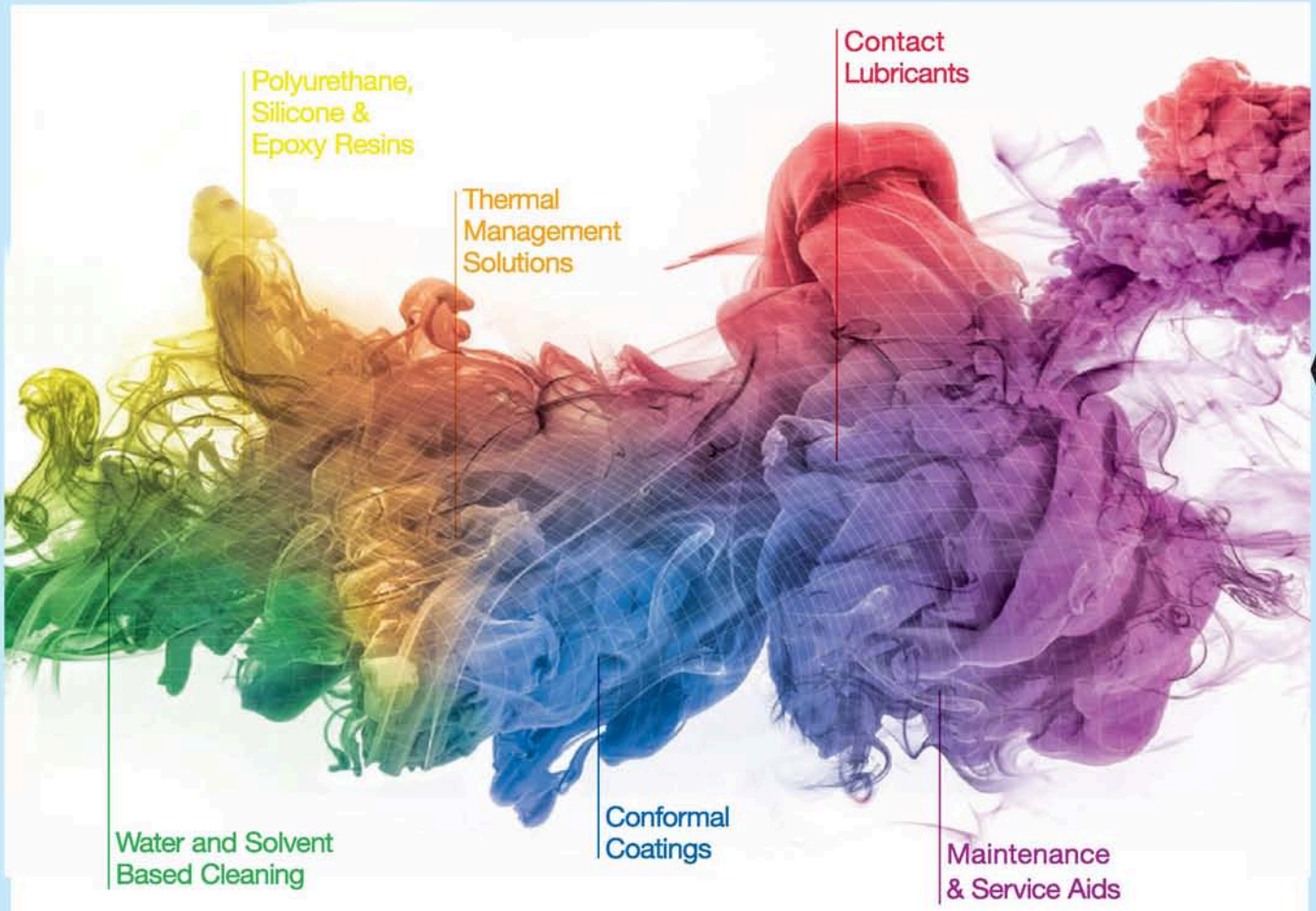

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Electrolube Launch New Encapsulation Resins at Electronex

Global electro-chemicals manufacturer Electrolube develops, manufactures and supports a wide variety of resin products and will showcase a new era of encapsulation resins on Stand B12 at Electronex Sydney.

One of the latest epoxy resins from Electrolube is a modified formulation of the company's ER4001 thermally conductive epoxy resin system, offering an improved method of cure and subsequent health and safety benefits for the user.

This resin is particularly suited to automotive applications (for both traditional and electric power train types) and is also ideal for use in LED lighting units where it helps to promote heat dissipation and prolong unit service life.

Electrolube will also launch two new polyurethane resins specifically aimed at helping LED lighting manufacturers provide environmental protection for their products. UR3638 is a tougher and low exotherm version of its 3634 product, providing a clear, transparent finish.

The low exotherm of this resin makes it particularly suitable for applications involving the encapsulation of larger LED lighting units. It is an aliphatic polymer offering superior UV stability as well as excellent transmission of visible light, making it an ideal resin for white light LEDs.

The second new polyurethane resin to be featured at the show is a low exotherm, low viscosity, low hardness, flexible, clear/transparent resin designed for encapsulating a variety of electrical components, but most particularly LEDs.

The level of flexibility achieved by the cured resin means that the connecting legs of components are not placed under high levels of stress during the cure.

Electrolube's polyurethane resins come in white, black, blue, clear straw, hazy/cloudy and optically clear formulations and, in common with the epoxy range, offer a host of properties to meet the needs of high-temperature environments and those exposed to chemical contamination, mechanical stress or shock and moisture ingress.

As with some types of polyurethane resin, optically clear silicone resins, such as Electrolube's SC3001, have superior resistance to UV light, and have been shown to maintain their clarity throughout rigorous laboratory exposure testing regimes. This well-documented UV resistance makes them ideal for LED applications where resin colour stability is important to achieving minimal colour temperature shift of the LED lighting unit itself.

If you would like to learn more about Electrolube's new resin products or learn more about how Electrolube can develop solutions to meet your specific needs, please visit the Electrolube team of experts on Stand B12 at Electronex.

Teledyne LeCroy – WaveRunner 8000 Digital Oscilloscope

Scientific Devices Australia (Stand B2) are showing the Teledyne LeCroy Model 8000 Digital Oscilloscope, offering a bandwidth range of 500MHz to 4GHz, with 40GS/s Sampling Rate including a collection of math, measurement, debug, and documentation tools providing unsurpassed analysis capabilities.

The WaveRunner 8000's MAUI User Interface with OneTouch optimizes convenience and efficiency by enabling all common operations with a single touch of the display. MAUI with OneTouch has revolutionary drag-and-drop actions to copy and set up channels, math functions, and measurement parameters without lifting a finger. Common gestures such as drag, drop, pinch and flick facilitate instinctive interaction with the oscilloscope. The "Add New" button quickly enables a new channel, math trace, or measurement while traces and parameters turn off with a flick of a finger. MAUI with OneTouch delivers a unique set of touchscreen gestures that simplifies measurement setup and brings unsurpassed efficiency and intuitiveness to oscilloscope operation.

Application-specific packages enable streamlined debugging for common design/validation scenarios including Digital Filtering, Spectrum Analysis, Device and Switching Power Supply analysis and more. Advanced customization enables user-defined parameters and math functions providing unique and limitless analysis capability. The WaveRunner 8000 has the greatest breadth and depth of tools, ensuring quick resolution of the most complicated debug tasks. More information on their website – www.scientific-devices.com.au

Membrane Switches – Connecting Man and Machine

Membrane switches are a reliable alternative to mechanical switches in electronic applications where low cost, visually appealing, durable inputs are required. They are a good choice for many industries including the medical, manufacturing, mining and transportation sectors to name a few. They can be completely sealed, making them dust proof, moisture resistant and are tough in the harshest of environments.

There are many variations of membrane switches but the most common are tactile and non-tactile switches. Tactile membrane switches provide immediate feedback to the user while non-tactile membrane switches do not and generally have a thinner profile. Tactile switches are the most desirable because of the assurance to the user that the switch has been closed.

Membrane switches can be constructed with multiple circuit layers, incorporating features such as embossed (domed) keypads, tactile responsive (clicker) stainless steel domes, or backlit with integrated LEDs. This can help provide the designer to create the ideal custom user interface.

Screen Process Circuits (stand A29) have a fully equipped graphic/engineering design and artwork-creation facility. From low cost prototypes to full production volumes, they offer a consistently reliable product at competitive prices.

They work very closely with clients to ensure specific customer requirements, in both performance and visual aesthetics, are met.

Website: www.screenprocesscircuits.com.au

HD Microscopes from Hawker Richardson

Hawker Richardson (Stand C2) will help you get "up close and personal" with their range of HD Digital Microscopes, on display at Electronex 2016.

The Mantis Elite-Cam HD is the latest update in the popular Mantis stereo microscope range. Combining the ergonomic benefits of unique eyepiece-less technology and with the imaging power of a high definition camera, Mantis Elite-Cam HD is the ideal solution for inspection, reworking and reporting.

The EVO Cam Quality HD Digital Microscope boasts a full HD (1080p/60fps) live video image, used predominantly for quality control, testing, inspection and documentation.

The Lynx EVO is a stereo microscope without eyepieces, giving stunning 3D imaging.

The Unicmp X-Ray, which will have live demonstrations, satisfies the needs for inspecting voids, bridging, opens, bond wire and so on.

Visit www.hawkerrichardson.com.au

Rolec OKW has a new range of "different" cases . . .

The new BODY-CASE is the latest product series in the range of wearable enclosures by OKW Geh usesysteme and is ideal for applications on or near the body.

Thanks to its small, compact format, it is perfect for wearing on the body: on your arm, around your neck, in shirt and trouser pockets or carried loose in an article of clothing.

The body case has a three-part design consisting of a top and a bottom part and a matt TPE sealing ring. The enclosures are made of ASA material in the colour traffic white and have a modern appearance thanks to highly polished surfaces. The top parts are available from stock, either with or without a recessed surface for decor foils or membrane keyboards. The sealing ring, available in vermilion and lava (similar to anthracite) colours allows protection classes IP65 and IP67. The dimensions of the enclosure are 54 x 45 x 17.5 mm (L x W x D). Possible applications include mobile data recording and data transmission, measuring and control engineering, digital communications technology, emergency call and notification systems as well as bio-feedback sensors in the fields of health care, medical technology, leisure and sports etc.

OKW enclosures can be customised on request, modification services include CNC milling and drilling, digital or screen printing of legends and logos, special finishes, EMC shielding, keypads and labels, all modifications are carried out by the in-house service centre.

Rolec-OKW will demonstrate the BODY-CASE and various other cases at Electronex 2016 stand D24.

Control Devices

APEM

THE BROADEST OFFERING
IN THE MAN-MACHINE INTERFACE MARKET

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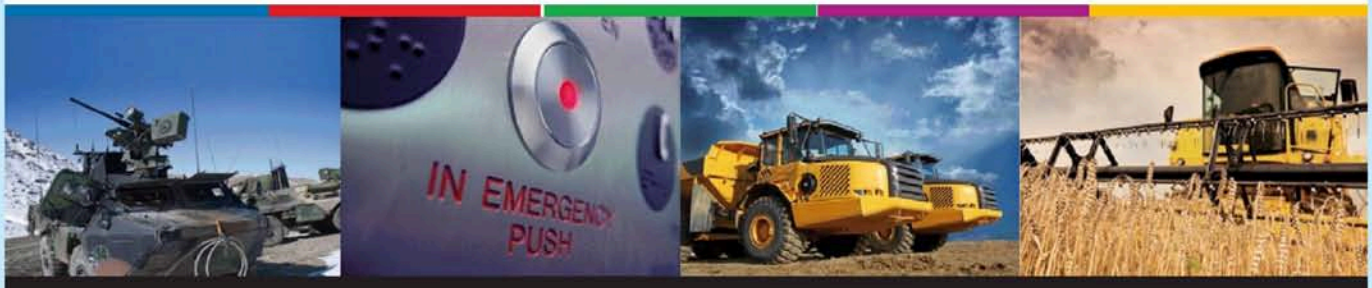

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A WORLD OF
SWITCHING CAPABILITIES

ALTRONIC Distributors demonstrates versatile new DIN rail timer

Amongst many of their other products, Altronic Distributors, on Stand C8 at Electronex 2016, will be demonstrating their new Versatile Timer with 35mm DIN rail mounting (S 0080).

It is fitted with four switched 24V outputs and four closing contacts which activate simultaneously.

It permits a total of 50 event switching times; each of which can be set to turn on any single day of the week or on multiple days for up to 24 hours. Switching events programmed for multiple days count as only a single station and each of the 50 event times may be set to any (but not multiple) output. Manual override is provided.

It also includes terminal covers.

Also available in the same product group are the 12V-24V DIN Rail Timer With Delay (S 0082) and the Temperature Controlled DIN Rail Switch (S 0086).

If you can't make it to Electronex 2016, call Altronic Distributors on 1300 780 999 or send an email to : sydney-wholesale@altronics.com.au; call in to any of their stores in Perth, Melbourne or Sydney, or visit www.altronics.com.au

Keithley High Current Source-Meter shown by Vicom

Vicom (Stand A6) will be demonstrating the Keithley 2461 High Current SourceMeter SMU Instrument.

It can create precisely-controlled 10A/100V, 1000W high-current pulses that minimise power device thermal effects and maintain device integrity. Its dual 18-bit high speed digitisers facilitate measuring actual device operation that can be graphically displayed right on the front panel for immediate analysis. The 2461 features the highest levels of DC and pulse source and sink performance in its class, enabling users to gain deeper insight into their designs.

The 2461 incorporates the simple and intuitive Touch, Test, Invent user experience that minimizes the learning curve and accelerates test setup for faster time to answer. The graphical touchscreen interface is similar to a smartphone or tablet and allows the user to quickly zoom in and out of data while conducting detailed analysis. A built-in open source scripting language enables users to create libraries of reusable, customizable test software for specialised measurement applications.

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Australian Made DEK and LPKF Solder Paste Stencils

DEK VectorGuard stencils, now manufactured in Australia by Mastercut.

DEK VectorGuard | LPKF ZelFlex | Standard Mesh Mounted

Reduce the overall cost of your stencils and simplify your stencil storage with a proven, reusable framing system. Frames for almost any stencil can be provided.

Benefits ...

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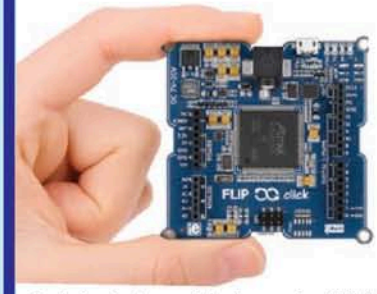

Arduino's two-sided cousin. While it may share many of the same attributes as the popular, open source platform including the 32-bit AT91SAM3X8E core of a Due, the pinout of an Uno and the ability to be programmed in the Arduino IDE via via microUSB, what really sets this new dev board from MikroElektronika apart is when you turn it over.

You'll find four mikroBUS sockets for "click boards." With more than 160 to choose from, Makers can prototype their next gizmo or gadget effortlessly by simply adding new functionality — ranging from Wireless, OLED displays to relays to sensors. That's 160^4 product combinations to set your imagination

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Analog Discovery 2: a High-Performance Pocket-sized All-in-One Instrument from Digilent

At Electronex 2016. Digilent have their Analog Discovery 2, a PC-based mixed-signal oscilloscope, logic analyser, spectrum analyser, waveform generator, data logger, variable power supply and more.

Makers and hobbyists can debug embedded systems, electronics, robotics or sensors with the free and easy to use software.

Engineers and designers can perform automated testing & control with LabVIEW and Python drivers.

Analog Discovery 2 can be connected to any PC (Mac, Linux, or Windows) over high-speed USB.

After viewing the Analog Discovery 2 at Digilent's stand at Electronex (Stand A23), you can purchase it from Blackbox (www.blackboxconsulting.com.au), the official distributor in Australia.

Glyn shows off new 4G LTE Router

On the Glyn & Telit stand (B8) you'll see the new Robustel 4G LTE Router with Dual Cellular Modules and Dual SIM for Mission Critical Applications.

Robustel has recently launched its latest 4G LTE router R2000 Dual with two cellular modules and two SIM cards for multiple carriers and continuous cellular connections, with fast network switching between modules (within 3 seconds) in case of network failure. This router is ideal for use in applications requiring a high reliability cellular network connection such as ATM, vending machines, retail POS, kiosks, branch offices, and convenience stores.

Robustel GoRugged R2000 Dual, available from IoTzone – powered by GLYN, is a rugged cellular router offering state-of-the-art mobile connectivity for machine-to-machine (M2M) applications. This router will primarily operate in 4G LTE with 3G/2G fallback and has RCM certification for Australia.

The R2000 Dual router also has 4 POE (Power Over Ethernet) ports which minimise installation costs in applications such as IP video surveillance and digital signage. 802.11b/g/n WiFi is also available with data rates of up to 300Mbps as well as a customisable captive portal. An Ethernet WAN port is also provided for uplink. Digital input for ignition control is available so the R2000 Dual router can be easily powered on or off in vehicular applications and a screwable terminal block allows for a more secure power supply.

Express PCB and Assembly Services from QualiEco Circuits Ltd.

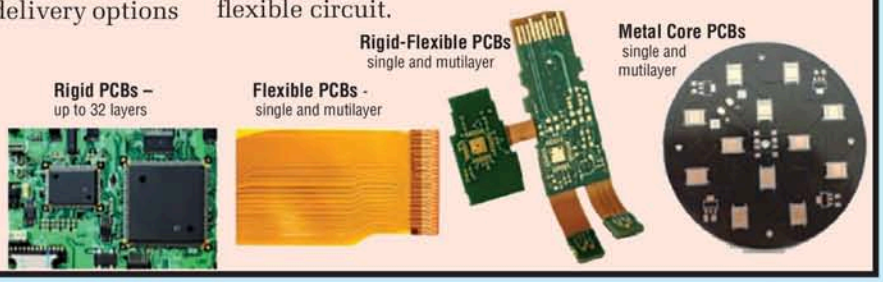
The Team at QualiEco Circuits Pty Ltd is well known for providing excellent quality electronic manufacturing services and solutions.

The company offers express services in all product categories. Our customers have been enjoying excellent quality, low prices and on-time delivery for years. The company has various customised delivery solutions for all customers at affordable prices. Customers can choose from the fastest to semi-fast and normal delivery options based on their budget and urgency.

This vibrant, growing company offers outstanding technical support and attention to detail. Proud of providing reliable services for more than 13 years, QualiEco Circuits is currently a market leader in New Zealand. The company is now enjoying a successful fifth year of operation in Australia.

Complete solution in specialised PCBs - Give wings to your imagination!

Visit the QualieEco stand at Electronex (Booth No A14) and ask for a special sample card with drill gauge manufactured in a blue coloured flexible circuit.



Suba Engineering demonstrating X-Ray

Suba Engineering will be glad to demonstrate their high-performance X-ray Inspection system, X-eye 5100F, designed for general non-destructive testing and failure analysis.

With 100kV micro-focus closed tube and high resolution flat panel detector equipped, X-eye 5100F provides high a quality X-ray image at high magnification.

With programmable multi-axis control, X-eye 5100F can inspect the object at any magnification. With Auto Teaching (CNC programming), the system can be used as a semi-automatic inspection system.

The X-eye 5100F has a user-friendly operating environment. Various measuring and annotation tools are included.

Applications include SMT assembly inspection for BGA void, open, missing and bridge connections and general solder joint inspection, along with wire bonding inspection and epoxy voids in semiconductors.

There's much more information on Suba Engineering's website, www.suba.com.au

Keysight: helping you unlock measurement insights

You've known them as the electronic measurement businesses of Hewlett-Packard, Agilent Technologies, and now, as Keysight Technologies.

For more than 75 years Keysight Technologies (Stand C11) have been helping you unlock measurement insights while providing the world's largest portfolio of handheld, portable and benchtop T&M instruments, plus a full suite of accessories, options and add-ons. Keysight's unique combination of hardware, software and people will help enable your next moment of insight, whether you're working on IoT, power supplies, batteries testing, cloud computing, PCBs, semiconductors, renewable energy or the latest glimmer in your imagination. Keysight is here to help you see what others can't – and then make it reality.

For information about Keysight solutions, you can also visit www.keysight.com or phone 1800 629 485.

TechRentals: Flexible Rental Options throughout Australia and Malaysia

TechRentals, exhibiting on stand A19, offers a vast range of test and measurement equipment for hire, rent, and sale. The TechRentals group is located in over 10 convenient sites spread across Australia and Malaysia; they are committed to putting in the hard work in to provide the right solution to get the job done. The group employs a team of over 200 staff members who possess the end-to-end knowledge and experience to deliver the best advice.

TechRentals has recognised the importance of innovation, ensuring that they have cutting-edge equipment that offers the most effective solutions. The company guarantees the best and most reliable equipment for you by ensuring that they invest in the highest quality products and our staff provides ongoing support.

The friendly team at TechRentals is dedicated to providing you with the highest quality of service, equipped with many years of knowledge and expertise to assist you with any concerns. They provide flexible rental options that they can customise to best suit your needs.

Website: www.techrentals.com.au

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USB 2.0 4 PORT SLIMLINE HUB

XC-4958

- USB 2.0 Type-A interface
- 30Mbps transfer speed
- 106(L) x 32(W) x 10(H)mm

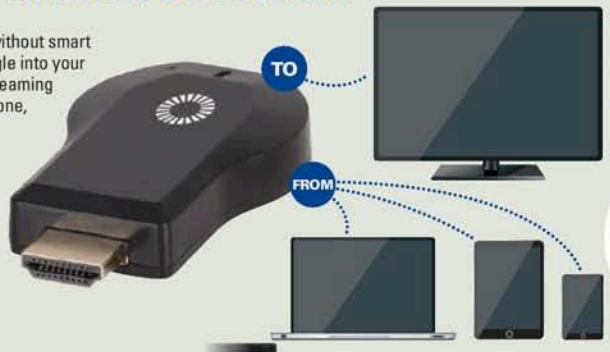
AVAILABLE EARLY SEPTEMBER

Wi-Fi HDMI MIRACAST DONGLE v2.0

AR-1922

A great solution for those without smart TVs. Plug this Anycast dongle into your TV HDMI port and begin streaming content from your Smartphone, Tablet or PC to your TV.

- Free AllConnect or iMediashare app from iTunes® or Google Play.
- Powered via USB port
- 58(L) x 39(W) x 13(H)mm



Full HD 1080

NEW

$54.95

AC600 LONG RANGE NETWORK ADAPTOR

YN-8313

- Detachable 3dBi antenna for improved Wi-Fi performance
- Dual band - switch between 2.4GHz (for 150Mbps) or 5GHz band (for 433Mbps).
- 50(L) x 16(W) x 12(H)mm

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NEW

NEW

$49.95

240V MAINS WI-FI WIRELESS SWITCH MODULE WITH APP MS-6126

Control mains powered devices via your Smartphone over the Internet.

- 240V@10A
- 53(W) x 50(L) x 16(D)mm

The App for this unit can be freely downloaded from Google® Play and App.Store.

NEW

$59.95

ANDROID PC MIRROR USB CABLE WC-7682

Displays what you see on your Android device's screen directly on your Windows computer screen.

- Supports all major brands of Android Smartphones and Tablets
- Charges Smartphone & Tablets
- 1.2m cable with USB Micro-B
- No app required

NEW

$79.95

5 PORT USB CHARGING STATION WITH STORAGE COMPARTMENT WC-7766

- Charge up to 5 Tablets or Smartphones side by side
- Max power output 2.4A per port. Total output 8.2A
- Includes 12VDC & 4A power supply.
- 165(L) x 120(W) x 62(H)mm

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USB TYPE-C LEADS

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WC-7906 **$19.95**

USB 3.0 A PLUG 1M
WC-7910 **$24.95**

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WC-7912 **$24.95**

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WC-7920 **$29.95**

FROM $19.95

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USB 3.0 GIGABIT ETHERNET CONVERTER WITH TYPE-C ADAPTOR YN-8412

Allows Modern Apple® MacBook® and Ultrabooks™ to connect to the internet using a LAN cable

- Maximises the data transfer speed
- Switch between Type-C and Type-A depending on the socket of the MacBook® or Ultrabook™
- RJ45 10/100/1000Mbps Network Connection
- 70(L) x 30(W) x 15(H)mm

NEW

$89.95

60W UNIVERSAL TYPE-C LAPTOP POWER SUPPLY MP-3340

- Automatically detects the optimum voltage output for the connected device (from 5,9,15 and 20V)
- Features both a USB Type-C port and USB 2.0 port
- Suitable for MacBook® and Google Chromebook™
- 100-240VAC, 1.5A
- 112(L) x 69(W) x 16(H)mm

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OUR KITS ARE GREAT FOR LEARNING ARDUINO®

NEW

$89.95

DUINOTECH EXPERIMENTS KIT XC-4287

A comprehensive kit, it includes an Arduino® compatible duinotech Uno board, a solderless breadboard, comprehensive user guide, extensive range of components, sensors, modules, pushbutton switches, jumper wires, LEDs, shift register IC and more.

MODULE LEARNING KIT XC-4286

This duinotech experiments kit contains a duinotech MEGA board, breadboard, jumper wires and a plethora of peripherals, neatly boxed in a plastic organiser.

See website for details.

$109

ARDUINO® COMPATIBLE MODULES & SHIELDS

$4.95

INFRARED TX MODULE XC-4426

Use your Arduino® to control your TV or Media Centre via Infrared.

- 5VDC operating voltage

$9.95

2.4GHZ WIRELESS TRANSCEIVER MODULE XC-4508

Communicate on the license free ISM band. Despite its diminutive size, it supports on-air data rates of up to 2Mbps. No external components are required (other than your Duino').

$4.95

LITHIUM BATTERY USB CHARGER MODULE XC-4502

This tiny module charges a single lithium cell from a 5V supply. Output via solder tabs, Input is either via solder tabs or a mini-USB port.

- 4.5V-5.5VDC input voltage
- 4.2V full charge voltage
- 27(L) x 19(W) x 5(H)mm

X AND Y AXIS JOYSTICK MODULE XC-4422

This handy module gives you X & Y axis control for your Arduino® project. The board is interfaced through 5 pin header and provides a small gamepad style joystick. There is also a tactile switch when you push the stick down.

- 47(L) x 25(W) x 32(H)mm

$5.95

OBSTACLE AVOIDANCE MODULE XC-4524

An inexpensive solution for an IR obstacle avoidance sensor, perfect for robotic projects with easy interface with Arduino® & compatible boards.

- Adjustable frequency and intensity
- 4 pin header
- 42(L) x 27(W) x 18(H)mm

$9.95

BLUETOOTH® MODULE XC-4510

Connected via the serial pins, and to your computer via Bluetooth®; this module creates a seamless serial-port link between you and your Duino' PLUS you can use it to communicate with your Bluetooth®-enabled Smartphone.

- 28(W) x 13(L) x 8(H)mm

$19.95

ETHERNET EXPANSION MODULE XC-4412

This network shield will allow you to set up your Arduino® as webserver, control your project over your network or connect to the web.

- 10/100Mb Ethernet port
- Reset button
- microSD card slot
- 69(L) x 48(W) x 14(H)mm

$39.95

$14.95

ETHERNET INTERFACE MODULE XC-4436

Contains all the circuitry required to implement a complete Ethernet interface. Use this with your latest duinotech project to send and receive email or host its own website!

- 3.3V operating voltage
- 160(L) x 60(D) x 15(H)mm

RS-232 SHIELD XC-4227

Connect a legacy device (or computer) to your existing Arduino® board and communicate with a huge variety of serial peripherals.

- MAX232 Chipset
- DB9 Female Socket
- RS-232 Voltage compliant
- 65(L) x 54(W) x16(H)mm

$34.95

BLUETOOTH® 4.0 SHIELD XC-4549

Brings the latest Bluetooth® 4.0 BLE (Bluetooth® Low Energy) to Arduino®.

- CC2541 Bluetooth® Chip Solution
- Startup time is only a few milliseconds
- UART interface and with baud rate setup function iBeacon

NEW

$59.95

SAVE UP TO 25% ON THESE ARDUINO® COMPATIBLE ACCESSORIES

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SAVE $5

USB LIPO CHARGER XC-4243 WAS $18.95

- 5V in from USB connection (micro USB, not included)
- Output to suit 3.7V single LiPo cell or parallel matched set of cells
- Status LEDs for charge and standby
- 500mA polyfuse to protect power source

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SAVE $9

OLED SHIELD XC-4269 WAS $33.95

Connect the 128x128 pixel OLED module (XC-4270) to your Arduino®. Analogue joystick with push-to-click, great for games.

- Piezo module for sound feedback
- Mount the OLED module directly on shield or independently using the supplied cable
- 75(W) x 54(H) x 46(D)mm

Limited stock. Check availability

NOW $29.95

SAVE $5

4-CHANNEL POE MIDSPAN INJECTOR XC-4254 WAS $34.95

Power up to four EtherMega's (XC-4256) or EtherTen's (XC-4216) with DC from a low cost plugpack across your home or office network cables.

- 4 channels of input/output jacks
- Commercial Power-over-Ethernet sources are not required
- 88(W) x 53(H) x 19(D)mm

NOW $34.95

SAVE $10

8 CHANNEL RELAY DRIVER SHIELD XC-4276 WAS $44.95

Drive up to 8 relays from your Arduino® using just 2 I/O pins with this shield.

- Plugs straight into your Arduino®-compatible board
- Individual LED status display on every output channel
- 52(W) x 66(H) x 12(D)mm

BUILD YOUR OWN Wi-Fi NOTIFIER

This project was inspired by one of our colleagues who wanted to be notified if his server room got too hot, so he came up with this neat tool and configured his notifier to alert him via email when the temperature reached a critical point.

With so many possibilities in the world of Arduino you could easily use this project to alert you on just about anything, even your water temperature for perfect soft boiled eggs. Maybe you need data reported back to you at a regular rate or you want to change the trigger to some other form of input. You decide!

Over to you. Have fun!

Please check instructions to test that it is compatible with your email provider before buying parts.

SEE STEP-BY-STEP INSTRUCTIONS AT
www.jaycar.com.au/wifi-notifier

$29.95

DUINOTECH LEONARDO BOARD
XC-4430

- Combines the chipset for the main controller and USB in a single IC.
- Boasts 12 analogue inputs and an extra PWM channel
- 75(W) x 53(L) x 13(H)mm

$5.95

ARDUINO® COMPATIBLE TEMPERATURE SENSOR MODULE XC-4494

Outputs an analog voltage that varies directly with temperature. Connect it straight to one of your duinotech analog inputs.

- Operating voltage: 5VDC
- Max 100°C
- 21cm Breakout cable included
- 33(W) x 22(D) x 9(H)mm

NEW

$19.95

ARDUINO® COMPATIBLE ESP-13 WI-FI SHIELD
XC-4614

Uses the powerful ESP8266 IC and has an 80MHz processor.

- Integrated TCP/IP stack
- Simple AT command interface with Arduino® main board
- Can be programmed directly with Arduino® IDE (separate programmer needed)
- Web configuration interface
- Switches on shield to disconnect from Arduino®

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BUY ALL FOR $49
SAVE OVER 10%

DIY

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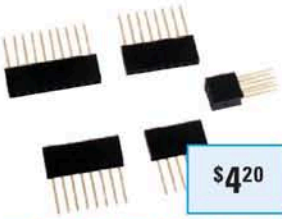
POLYMORPH PELLETS
NP-4260

It's a commercial grade thermoplastic that softens enough to be formed into any shape at around 62 - 65° C. You simply heat the pellets in hot water or with a hair dryer. It can be drilled, sanded, ground, machined or heated and reformed again and again.

Supplied in a 100g bag of 3mm pellets.



$4.20

NERD PERKS 2x POINTS

STACKABLE HEADER SET
HM-3207

The perfect accessory to the ProtoShields and vero type boards when connecting to your Arduino® compatible project.

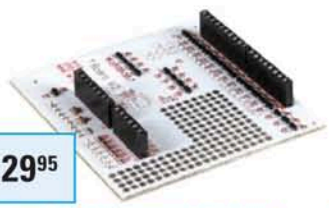
- 1 x 10-pin
- 2 x 8-pin
- 1 x 6-pin
- 1 x 2x3-pin (for ICSP)

TOUCH SCREEN MONITOR & PCDUINO BUNDLE

Included is 7" colour LCD with capacitive touch and a resolution of 1024 x 600 (screen, driver board, ribbon cable & jumper wires included) PLUS A pcDuino v3.0 (a full sized single board computer, with 1GHz processor,1GB Ram, HDMI, LVDS connector for LCD display and built in Wi-Fi).

PCDUINO V3.0 WITH WI-FI XC-4350 **$129**
TOUCH SCREEN MONITOR XC-4356 **$149**

NERD PERKS CLUB OFFER
BUY BOTH FOR $249
SAVE $29



$29.95

VOLTAGE CONVERTER MODULE FOR XC4350/52 PCDUINO XC-4362

- pcDuino runs at 3.3V
- Marries 5V Arduino shields with the 3.3V pcDuino
- Provides bi-directional voltage translation
- 70(L) x 50(W) x 4(D)mm

$59.95

PCDUINO 5MP CAMERA XC-4364

- Connects directly to your pcDuino V3.0
- Captures an active array video and images up to 2592 x 1944
- 9(L) x 9(W) x 6(D)mm
- Ribbon Lead Length: 90mm

$5.95 ea

150MM PLUG TO PLUG JUMPER LEADS 40 PIECE

A pack of 40 jumper leads of various colours for prototyping. Ideal for Arduino® and DIY projects. Each flexible lead is 150mm long with pins to suit breadboards or PCB headers.

PLUG TO PLUG WC-6024
SOCKET TO SOCKET WC-6026
PLUG TO SOCKET WC-6028

$19.95

SOLDERLESS BREADBOARD WITH POWER SUPPLY PB-8819

For circuit board prototyping and Arduino® projects. Powered from a 12V plug pack or from 5V using the micro USB socket with switchable output between 3V and 5V DC.

- 1 x Solderless Breadboard with 830 Points
- 1 x Power Supply Module
- 64 mixed jumper wires of different lengths and colours

TOOLS OF THE TRADE FOR YOUR IT & COMMS

There has been an obvious resurgence in people getting back to the workbench and reviving skills involving manual dexterity. As you will see across the following pages, Jaycar has all the DIY tools you'll need to equip your workbench so you can create projects from the power of your brain and your hands.

1. DESKTOP PCB HOLDER WITH ADJUSTABLE ANGLE TH-1980 **WAS $19.95**
- Suitable for different shaped components, connectors, soldering strips, etc.
- 200(L) x 140(W)mm maximum holding size

2. 2 IN 1 NETWORK CABLE TESTER AND DIGITAL MULTIMETER XC-5078
- Remote terminator included.
- 600V, 2000 count
- AC/DC voltages up to 600V
- Test leads and carry case included
- 162(L) x 74.5(W) x 44(D)mm

3. 22 PIECE LONG BIT SCREWDRIVER SET WITH CASE TD-2114
- Selection of popular slotted, Phillips, Star and TRI bits

See website for contents

4. LED HEADBAND MAGNIFIER QM-3511
- Fits over prescription or safety glasses
- Adjustable head strap
- 1.5x, 3x, 8.5x or 10x magnification.
- Requires 2 x AAA batteries

5. 150MM PRECISION SIDE CUTTERS TH-1891 **WAS $39.95**
- High quality carbon steel
- Insulated soft-touch handles

6. PORTABLE 12 COMPARTMENT STORAGE CABINET HB-6301 **WAS $44.95**
- "Double lock" closure on each storage box
- 2 large, 4 medium and 6 small boxes
- 300(W) x 310(H) x 145(D)mm attaché-case

ECONOMY CATIII DMM

DATA HOLD QM-1517

PERFECT FOR THE ELECTRONICS ENTHUSIAST OR STUDENT.
- 600V, 2000 count
- Square wave output
- Backlit display
- Continuity buzzer
- 115(L) x 65(W) x 30(H)mm

INCLUDES QUALITY TEST LEADS.

$14.95

DATA HOLD CATIII DMM

NON-CONTACT VOLTAGE DETECTION QM-1527

LOTS OF FEATURES, GREAT PRICE.
- 500V, 2000 count
- 19 range
- Diode test
- 10A DC current
- Data hold
- Backlight
- Continuity beeper
- 145(H) x 65(W) x 35(H)mm

INCLUDES QUALITY TEST LEADS.

$19.95

AUTORANGING CATIII DMM

NON-CONTACT VOLTAGE DETECTION QM-1529

AN EXCEPTIONAL VALUE FOR MONEY DMM SUITABLE FOR KEEN HOBBYISTS.
- 600V, 2000 count
- Backlight
- Data Hold
- Auto power off
- 144(L) x 70(W) x 32(H)mm

INCLUDES QUALITY TEST LEADS.

$24.95

JUST ARRIVED! ALL NEW MULTIMETERS AVAILABLE ONLINE & IN STORE

WIN $50 JAYCAR GIFT VOUCHER!

SIMPLY SUBMIT A PHOTO OF THE JAYCAR TOOL YOU CAN'T LIVE WITHOUT AND YOU COULD WIN.

IT'S THAT EASY!

win.jaycar.com/workbench

Competition closes 23rd Sep. See website for the T&Cs

3V TO 15 VOLT DC 40 AMP REGULATED SWITCHMODE LABORATORY POWER SUPPLY MP-3090

Incredibly light for output capacity, weighing only 3.5kgs.
- Variable output voltage from 3 to 15VDC, or it can be fixed at 13.8VDC
- The unit has overload, over temperature and over voltage protection
- 220(W) x 110(H) x 300(L)mm

FREE HIGH QUALITY BANANA PIGGYBACK TEST LEADS FOR NERD PERKS CARD HOLDERS*
WT-5326 **Valid with purchase of MP-3090*
WT-5326 VALUED AT $29.95

$379

ESD SAFE GOOT TEMPERATURE CONTROLLED SOLDERING STATION WITH DIGITAL DISPLAY

TS-1440 **RRP $299**

Precision, Japanese manufactured with excellent temperature stability and anti-static characteristics.
- 230-240VAC supply voltage
- 65 Watt capacity heater
- 200 - 480°C temperature range
- 0.5mm tip supplied

NERD PERKS SPECIAL $279
SAVE $20

TELEPHONE EXTENSION RINGER YT-6068

Increase the volume or relocate the ringer of your landline phone. Wall mountable, on/off switch.

- Multiple tone and pitch selection
- Volume control
- Multiple input types
- 8-12 ohm output for horn speaker
- No battery or external power required
- 155 x 90 x 30mm

NEW

$29.95

TELEPHONE ISOLATION ON HOLD KIT YT-6070

Great for the small office or business owner.

- Accepts input via 3.5mm headphone socket
- Works with any MP3 player
- Includes an RCA adaptor
- 75 x 28 x 21mm

See website for details.

NERD PERKS
BUY 2 FOR $23.90
SAVE $10

CAT 5 UTP SPLITTER

YT-6090 **$16.95 EA**

Save time, money and space! Usually used in pairs, this UTP splitter enables two different devices to share the same Cat5 cable.

Cannot be used to run two computers from one network and not suitable for gigabit networks.

NEW

$29.95

FROM $29.95

COMPACT 8-PORT ETHERNET SWITCHES

Enhance network performance and efficiency.

- Features 8 x RJ-45 ports
- Includes power supply & USB adaptor
- 137(L) x 76(W) x 25.5(H)mm

TWO MODELS AVAILABLE:

10/100MBPS YN-8077 **$29.95**
10/100/1000MBPS YN-8078 **$64.95**

$69.95

GIGABIT POE INJECTOR YN-8047

Use Power over Ethernet (POE) devices while being connected to a standard network switch or modem/router. Features remote power feeding up to 100m.

- 100-240VAC input voltage
- 10/100/1000Mbps network speed
- IEE 802.3af, IEE 802.3at PoE standards
- 155(L) x 58(W) x 36(D)mm

$119

5 PORT POWER-OVER-ETHERNET (POE) SWITCH YN-8071

Power up to 4 devices on your network.

- 4 x PoE, 1 x Uplink ports. 55W power output (up to 30W per port)
- 10/100Mbps peak throughput. Standard is 802.3af, 802.3at
- 100m transmission distance
- 55V, 1.25A power supply
- 160(L) x 92(W) x 28(D)mm

KEYSTONE WALL PLATES

Flush type wall plates to accept our standard keystone 110 jacks. Fits standard Australian electrical switch plate installation hardware and screw centres.

- Supplied without keystone jacks
- 70(W) x 114(H) x 6(D)mm

SINGLE WHITE YN-8050 **$2.50**
DOUBLE WHITE YN-8052 **$2.50**
TRIPLE WHITE YN-8054 **$2.75**
QUAD WHITE: YN-8056 **$2.90**
6-WAY WHITE YN-8058 **$2.90**

FROM $2.50
NERD PERKS 2x POINTS

INSERTS FOR KEYSTONE WALLPLATES

A range of inserts to cater for computer and Audio video applications. They fit standard 110 keystone wall plates and allow to configure your installation any way you like.

RJ45 SOCKET CAT5E YN-8028 **$4.95**
RJ45 SOCKET CAT6 YN-8029 **$4.95**
RIGHT ANGLE USB 2.0 SOCKET PS-0795 **$5.50**
USB B - USB A PS-0753 **$4.95**
USB A -USB A SKT PS-0773 **$4.95**
USB 3.0 - USB 3.0 PS-0799 **$12.95**

YN-8028

PS-0795

FROM $4.95
NERD PERKS 2x POINTS

CAT-5 PUNCH-DOWN TOOL TH-1738

This versatile little tool will strip wire up to 5-6mm, and doubles as a punch-down tool for 110/88-type terminals, with blade.

SEE PAGE 6 FOR CABLES

$8.95
NERD PERKS 2x POINTS

$19.95
NERD PERKS 2x POINTS

$22.95
NERD PERKS 2x POINTS

CAT5 ADJUSTABLE PUNCH-DOWN TOOL TH-1740

Designed for seating wire into terminal blocks and has an adjustable internal impact mechanism. Supplied with 88 blade. 152mm long.

ALSO AVAILABLE:
110 REVERSIBLE KRONE BLADE TH-1743

6P / 8P MODULAR CRIMPING TOOL TH-1935

This tool will crimp the following plugs: 6P2C, 6P4C - RJ11, 6P6C - RJ12, 8P - RJ45. Cuts and strips the cable.

ALSO AVAILABLE: 4P/6P/8P/10P MODULAR CRIMP TOOL TH-1936

PL-0978

FROM $4.95

SERIAL ATA CABLES

A range of SATA data and power cables for use with computers and external serial ATA devices.

SATA TO SATA DATA PL-0978 **$5.95**
HDD POWER TO 2 X HDD PL-0750 **$4.95**
HDD POWER TO 2 X SATA PL-0759 **$7.95**

$39.95

SATA TO USB 3.0 ADAPTOR XC-4149

A simple way to access files temporarily on a SATA hard drive you no longer have installed. Includes USB 3.0 cable and mains adaptor.

USB 3.0 SATA HDD DOCKS

Easily backup and store gigabytes of data quickly. Suits 2.5"/3.5" SATA HDD's (not included). USB 3.0 cable and power supply included.

SINGLE XC-4696 **$49.95**
DUAL XC-4697 **$69.95**
SINGLE CLOUD DOCK XC-4691 **$59.95**

FROM $49.95

XC-4696

HDD not included.

3.5" SATA HDD ENCLOSURE WITH USB 3.0 XC-4667

- Plug 'n' Play
- Hot swappable
- For 3.5" HDDs only (not included)
- Supports SATA I/II/III
- Supplied with USB 3.0 cable and mains adaptor

$59.95

50 OHM RG58U SOLID CORE COMMUNICATION CABLE

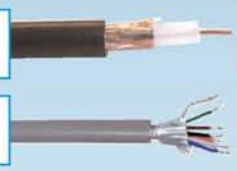
WB-2010 **$120/roll**

Suited up to 500MHz.

- Ideal for CB, marine, amateur and two-way radio
- Sold per metre or 100m roll

$1.45/m

FROM $1.90/m



50 OHM RG213/U COMMUNICATION CABLE

WB-2015 **$379/roll**

- Commonly used in UHF
- Sold per metre or 100m roll

$4.50/m

FROM $1.85/m

TELEPHONE CABLE

Flat cable. Ivory colour.

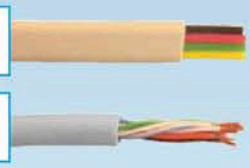
- ACA approved.
- Sold per metre or 100m roll

2 PAIR (4 WIRE) WB-1620 **$0.70/m or $59/roll**

3 PAIR (6 WIRE) WB-1622 **$0.90/m or $79 /roll**

FROM 70¢/m

$1.45/m



RAINBOW CABLE 16 CORE

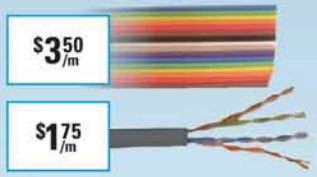
WM-4516 **$95/roll**

Colour coded strands of insulated conductor bonded together in a flat cable.

- Same rating as 13 x 0.12mm light duty hook- up wire.
- Sold per metre or 33m roll

$3.50/m

$1.75/m



COMPUTER CABLE

- Two cables suited for computers etc.
- All are shielded to stop RFI.
- Sold per metre or 100m roll

6 WAY WB-1575 **$1.90/m or $159/roll**

9 WAY WB-1578 **$2.20/m or $189/roll**

IDC RIBBON COMPUTER CABLE

Designed for IDC connectors.

- Grey in colour with red trace.
- Sold per metre or 33m roll

16 WAY WM-4502 **$1.85/m or $48/roll**

26 WAY WM-4504 **$2.95/m or $82/roll**

50 WAY WM-4508 **$5.95/m or $169/roll**

CAT 5 SOLID NETWORK CABLE

Single strand Cat 5e, used for long runs in permanent installations.

- A Tick approved
- 100MHz
- Sold per metre or 100m roll

8 CORE STRANDED
WB-2020 **$1.45/m or $125/roll**

SOLID CORE SINGLE STRAND
WB-2022 **$1.45/m or $125/roll**

CAT6 SOLID CORE UTP CABLE

WB-2030 **$149/roll**

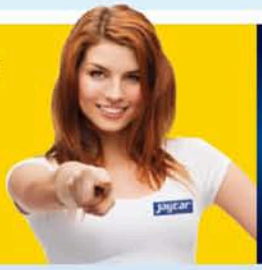
Designed for reliable high-speed network installations

- Suitable for IDC terminations on patch panels and wall plates
- 4x24 AWG solid core twisted pairs
- Sold per metre or 100m roll

NERD PERKS CLUB MEMBERS RECEIVE:

10% OFF

COMMUNICATION, TELEPHONE, COMPUTER DATA ROLL CABLES



EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!

Conditions apply. See website for T&Cs

REGISTER ONLINE TODAY BY VISITING: www.jaycar.com.au/nerdperks

HOW TO CRIMP CAT5/6 CABLES

1. Determine the amount of cable you will need.
2. Cut the cable length.
3. Prepare the ends of the cable for crimping.
4. Place the cable ends into the RJ-45 connectors (use PP-1438/39, p6).
5. Determine the orientation of the wires.
6. Line the 8 wires up neatly so that they will fit into the plastic head.
7. Crimp the head onto the cable (use TH-1935, p5).
8. Test your cable if desire (use XC-5078, p4).

8 PIN US TYPE TELEPHONE PLUG FOR SOLID CORE CABLE

FROM $6.95

8/8 RJ45 Approved.

PKT 6 PP-1438 **$6.95**

PKT 50 PP-1439 **$34.95**

RJ45 RUBBER BOOTS

FROM $4.95

PK 10 PM-1441 **$4.95**

PK 50 PM-1442 **$15.95**

$19.95

WATERPROOF RJ45 JOINER IP68

PS-4064

Includes 2-way Cat5 joiner, but will also accommodate any connector that fits within the internal dimensions of the housing.

- IP68 rating
- Accepts cables 4 - 7mm Dia.
- 120(L) x 35(Dia.)mm

CAT6A PATCH LEADS

Upgrade your home or office network to speeds up to 10Gbps

- Blue sheathed
- All models are ACMA approved

0.5M YN-8292 **$3.95**

1.0M YN-8293 **$4.95**

2.0M YN-8294 **$7.95**

3.0M YN-8295 **$9.95**

5.0M YN-8296 **$14.95**

10.0M YN-8297 **$24.95**

20.0M YN-8298
NEW $34.95

30.0M YN- 8299
NEW $44.95

FROM $3.95

FROM $27.95

RS-232 DB9M CONVERTERS

Connect a variety of RS-232 devices to your modern computer with these adaptors.

TO USB ADAPTOR XC-4927 **$27.95**

TO USB 1.5M XC-4834 **$29.95**

$39.95

USB TO PARALLEL BI-DIRECTIONAL CABLE XC-4847

Print to most parallel printer devices through your computer's USB port. The device replicates the old 25 pin printer socket and provides up to 12Mbps data throughput; Printing is significantly faster compared with standard a parallel port connection.

- Plug & Play support

$89.95

USB TO RS-485/422 CONVERTER XC-4132

Wire up an RS-485/422 device to the 4 socket terminal block to give your hardware USB connectivity. Surge protected. Suitable for industrial, military, marine, science and custom built applications.

- 610mm USB A Male to Male cable included

PROTECT YOUR I.T. SETUP WITH UNINTERRUPTIBLE POWER SUPPLIES

$129 MP-5214

$139 MP-5224

$319 MP-5207

$449 MP-5212

Protect your valuable setup with our value-for-money Uninterruptible Power Supplies. Keep your systems running long enough to save critical data when the mains power fails. Other models in-store or online.

MP-5224	MP-5214	MP-5207	MP-5212
Line interactive, economical model	Line interactive, desktop model	Line interactive, smart LCD desktop model	On-line, smart LCD rack mountable (2U height)
600VA, 300W	650VA, 360W	1500VA, 900W	1000VA, 700W
12V/7AH x1	12V/7AH x1	12V/9AH x2	12V/7AH x3
Modified Sine Wave	Modified Sine Wave	Modified Sine Wave	Pure Sine Wave
Transfer <10 ms	Transfer <10 ms	Transfer <10 ms	Instant Tranfer
6 x AUS (3 bypass, 3 mains)	2 x AUS mains	2 x AUS mains	6 x IEC
Backup time: 31 mins / 11 mins / 4.5 mins	Backup time: 25 mins / 9 mins / 5 mins	Backup time: 94 mins / 49 mins / 31 mins	Backup time: 95 mins / 47 mins / 32 mins

NERD PERKS CLUB MEMBERS SAVE
ON JAYCAR'S RACK MOUNT CABINETS & ACCESSORIES

Ideal for IT or phone system installations, studios and PA systems. These cabinets are solid steel powder coated to provide high strength and rigidity under load and are packed flat for convenient transport. These 19" rack mount hardware are value for money with outstanding features found on more expensive units.

NERD PERKS FROM $64.95 SAVE $10

EQUIPMENT CABINET
ALUMINIUM FRONT PANEL

1 UNIT HB-5120
RRP $74.95 NERD PERKS $64.95 SAVE $10

2 UNIT HB-5125
RRP $119 NERD PERKS $109 SAVE $10

3 UNIT HB-5130
RRP $129 NERD PERKS $119 SAVE $10

NERD PERKS FROM $159 SAVE $20

FIXED FRAME
CLEAR TEMPERED GLASS DOOR

6U RACK HB-5170
RRP $179 NERD PERKS $159 SAVE $20

12U RACK HB-5174
RRP $229 NERD PERKS $209 SAVE $20

NERD PERKS FROM $249 SAVE $20

SWING FRAME
CLEAR TEMPERED GLASS DOOR

6U SWING FRAME HB-5180
RRP $269 NERD PERKS $249 SAVE $20

12U SWING FRAME CAT HB-5182
RRP $329 NERD PERKS $309 SAVE $20

NERD PERKS SPECIAL $24.95 SAVE 15%

PATCH LEAD MANAGEMENT PANEL HB-5434 RRP $29.95
1U size, keeps all your patch leads under control.

NERD PERKS FROM $41.95 SAVE 15%

CAT 5/6 24-PORT PATCH PANELS
24 port patch panel with a hard metal exterior. Numbered ports and a labeling area for each port.

CAT 5 YN-8046
RRP $49.95 NERD PERKS $41.95 SAVE $8

CAT 6 YN-8048
RRP $69.95 NERD PERKS $58.95 SAVE $11

NERD PERKS SPECIAL $58.95 SAVE 15%

6-WAY POWER DISTRIBUTION UNIT MS-4094 RRP $69.95
Power up to six 240VAC components in your rack setup. Surge/overload protected and fits any standard 19" rack. Includes 1.6m power lead. 1U rack space.

NERD PERKS FROM $20.95 SAVE 15%

RACK CABLE SUPPORTS
Take the pain out of wiring and fault-finding rack cabinets. These high quality supports keep your cables organised and neat, and provides strain relief at the same time.

1U RACK HB-5430
RRP $24.95 NERD PERKS $20.95 SAVE $4

2U RACK HB-5432
RRP $29.95 NERD PERKS $24.95 SAVE $5

NERD PERKS FROM $15.95 SAVE 15%

BLANK PANELS
Black powder coated panels for filling in unused space or configuring to your own requirements. Mount hardware included.

1U RACK MOUNT BLANK PANEL - VENTED HB-5424 **RRP $18.95 NERD PERKS $15.95 SAVE $3**

2U RACK MOUNT BLANK PANEL - VENTED HB-5426 **RRP $27.95 NERD PERKS $22.95 SAVE $5**

NERD PERKS FROM $40 SAVE 15%

RACK SHELVES
Ideal for equipment withoug rack-mounting ears. Each shelf has ample slots for ventilation and takes loads of up to 20kg.

1U FIXED RACK SHELF HB-5452
RRP $49 NERD PERKS $40 SAVE $9

2U FIXED RACK SHELF HB-5454
RRP $69 NERD PERKS $58 SAVE $11

1U BALL BEARING SLIDING RACK SHELF HB-5450 **RRP $99.95 NERD PERKS $84.95 SAVE $15**

NOW $89.95 SAVE $10

WIRELESS N300 ADSL2+ ROUTER WITH USB STORAGE
YN-8342 **WAS $99.95**

Network speeds of up to 24Mbps downstream and 1Mbps upstream. Wi-Fi. 802.11b/g/n compatible. USB port to easily share files from a USB HDD over the network. 300Mbps.

NOW $99 SAVE $20

5-IN-1 WIRELESS AC750 DUAL BAND ROUTER
YN-8329 **WAS $119**

Router, access point, range extender, Wi-Fi bridge or WISP. 2.4/5GHz. 802.11ac router with Wi-Fi speeds of up to 750Mbps. Good Wi-Fi coverage and fast speeds without the mess of cables.

CAN'T DECIDE?
TRY A JAYCAR GIFT CARD
See website for T&Cs

I.T., COMMS & ARDUINO® COMPATIBLE SHIELDS

CLEARANCE

Limited stock. Not available online. Contact store for stock availability.

SD CARD SHIELD

FOR ARDUINO® XC-4552 **WAS $24.95**

- Supports SD, SDHC, or MicroSD TF cards
- 3.3V operating voltage

NOW $19.95
SAVE $5

TOUCH SHIELD

FOR ARDUINO® XC-4551 **WAS $39.95**

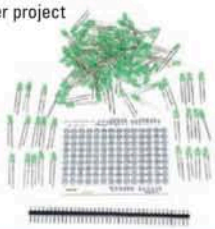
- 9 capacitive touch pads
- Up to 12 touch sensitive buttons
- Works with 5V and 3.3V boards

NOW $29.95
SAVE $10

LOL SHIELD

FOR ARDUINO® XC-4546 **WAS $39.95**

- Display anything in a 9 x 14 grid.
- 126 individually controlled LEDs
- Great DIY solder project



NOW $29.95
SAVE $10

Wi-Fi/ETHERNET SHIELD

FOR ARDUINO® XC-4548 **WAS $159**

- Accepts music being pushed over Airplay for iOS devices or DLNA compatible devices including Android.
- Includes Shield, Wi-Fi module & Antenna cable

NOW $129
SAVE $30

USB 2.0 TYPE-C TO USB SOCKET ADAPTOR PA-0928 WAS $6.95

ALSO AVAILABLE:

SAME WITH 15CM CABLE
WC-7908 **WAS $9.95 NOW $5.95 SAVE $4**

NOW $4.95
SAVE $2

VGA & R/L AUDIO TO HDMI SCALER CONVERTER

AC-1617 **WAS $89.95**

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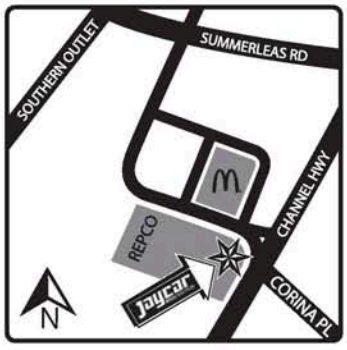

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Taiwan's BOOMING electronics industry

By Leo Simpson

While manufacturing in Australia is subject to unrelenting pressures from high labour costs and a somewhat elevated currency, the picture in Asia is radically different. That is particularly the case in Taiwan which has a booming electronics industry with thousands of companies turning out a mind-boggling range of products, ranging from simple items like plugs and sockets to the most complex, like computers and semiconductors.

No company typifies the scene better than Taiwan Semiconductor Manufacturing Company which had a net revenue of $35.4 billion in 2015.

A large number of American and other western technology companies have manufacturing plants in Taiwan, together with often-bigger plants in mainland China.

But while many of the western high-technology companies have a big presence in Taiwan, the country also has thousands of its own home-grown companies which are competing strongly on the world market and also servicing the needs of other electronics companies in Taiwan itself.

And while the cost of labour in Taiwan is certainly lower than in the Australian market, no-one should be under the illusion that working conditions in Taiwan are worse than in Australia or that technical standards are lower.

That would be entirely wrong, as was confirmed by my recent trip to Taiwan. In that brief visit, I joined a group of journalists from other countries, at the invitation of the Taiwan Trade Commission, as a preview to Taitronics, the Taipei International Electronics Show, to be held between October 6-9, 2016 (www.taitronics.tw). In three days, we made plant inspections of eight companies, some which are represented in Australia.

This is a small segment of one of the exhibition halls for last year's Taipei Electronics Show. This year's show will be held from 6th to 9th October in Taiwan.

This helicopter made by Geosat has a rotor diameter of 1.9 metres and a payload of 13kg, making it ideal for crop spraying applications. It was surprisingly quiet.

To say that these plant tours were an eye-opener would be an understatement. These plants are very modern, with highly qualified engineering staff, the very latest in manufacturing techniques and highly trained and motivated assembly line workers.

Nor would the very small sample of firms we visited be likely to give an unduly rosy picture. As I criss-crossed Taipei and also visited Taichung City over five days, it was abundantly clear that a large majority of manufacturing facilities in Taiwan are very large and modern.

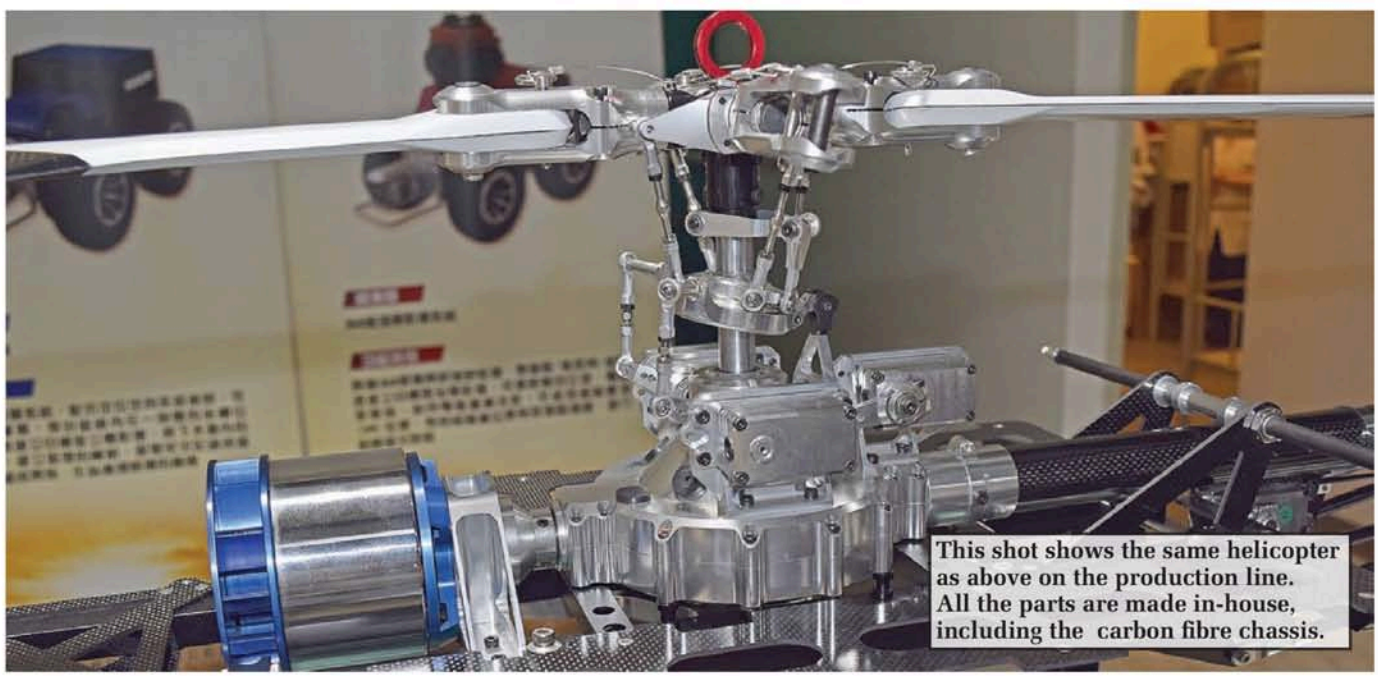
In fact, to give an idea of the high standards involved, most of these plants we visited were fully air-conditioned and we had to don protective head and footwear before we were admitted to the factory floors. This was not to protect us – it was to avoid tracking dirt into their very clean plants. Furthermore, in some plants we had to don full plastic suits and go through air locks into clean rooms.

The eight companies visited, in chronological order, were Chroma Ate Inc; Good Will Instrument Co, Ltd; Mean Well Enterprises Co, Ltd; Excel Cell Electronic Co, Ltd; Geosat Aerospace & Technology Co Ltd; Printec H.T. Electronics Corp; Kinsun Industries Inc and Tenmars Electronics Co, Ltd. Some of these will already be familiar to SILICON CHIP readers, such as Good Will and Meanwell but most of the others are probably unknown, even though their products could well turn up in equipment sold in Australia.

Chroma Ate Inc (www.chromaate.com) was the first company we visited and it has more than 1900 employees spread across two production facilities. They have a diverse product range which is broadly split into a video range, mainly centred around comprehensive testing of flat panel displays; and their power electronics range, mainly devoted to load testing of large batteries, chiefly those used in electric vehicles.

Geosat Aerospace

This company is based in Taichung City and the tour group travelled


This shot shows the same helicopter as above on the production line. All the parts are made in-house, including the carbon fibre chassis.

At this soldering station at the Mean Well plant, two switchmode power supplies are about to be dipped into a solder bath as the final step in PCB assembly.

there from Taipei on the very impressive HSR train which made short work of the 170km trip between the two cities, reaching speeds up around 290km/h (Australia – eat your heart out!).

Geosat (www.geosat.com.tw) specialises in the manufacture of relatively large multi-rotor helicopters and fixed wing UAVs (drones). Typical of the multi-rotor designs is a hexacopter with a take-off mass of 9kg and a payload of 1.5kg, mainly intended for mapping and surveying.

Much more impressive was their unmanned helicopter which has a main rotor diameter of 1.9 metres, a maximum take-off mass of 20kg and a payload of 13kg. And the motive power? A single out-runner brushless motor with a high capacity Lithium polymer battery pack.

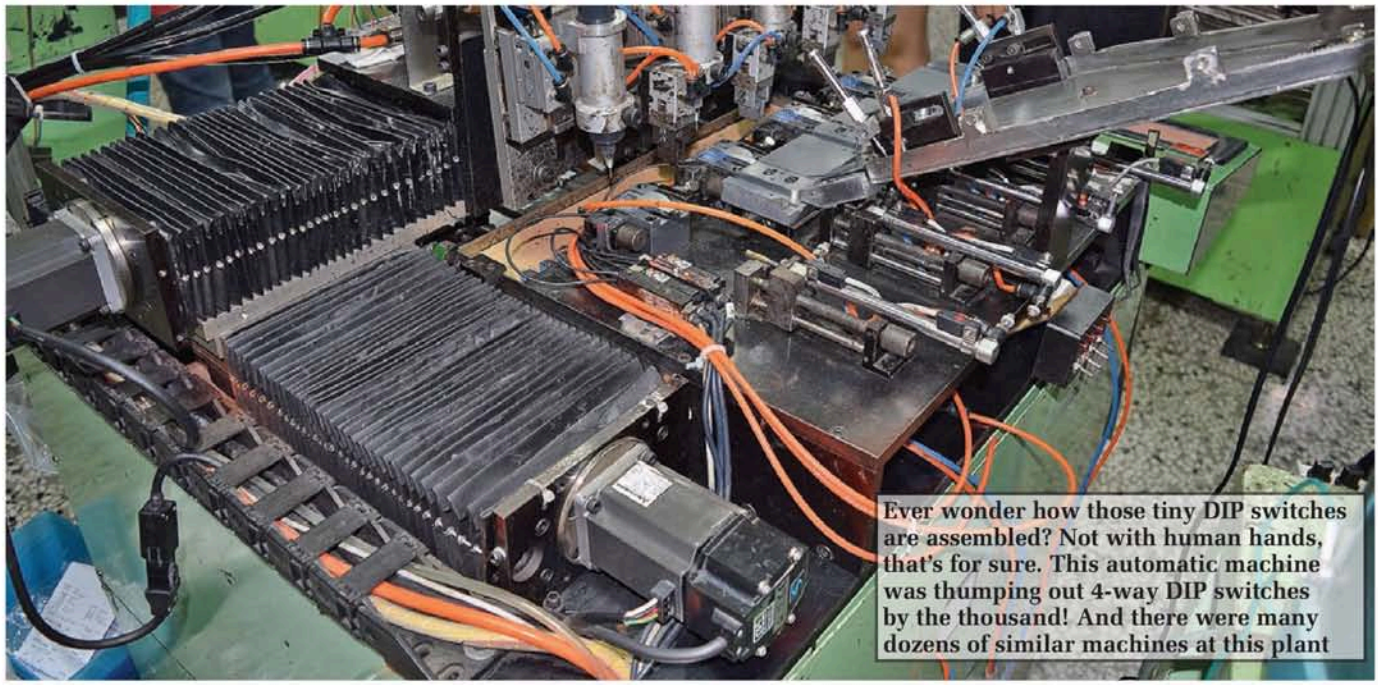
It is mainly intended for crop spraying but since it is surprisingly quiet, it could have quite range of other interesting applications. Its maximum flight duration with that payload is 30 minutes.

Compared with conventional piloted helicopters or fixed wing aircraft, the Geosat helicopter would have considerable advantages for crop dusting. No doubt they could have precise GPS way-points for spraying paddocks and the fact they can safely fly much lower than piloted aircraft would mean less over-spray onto adjacent paddocks and crops.

In fact, they could fly all day on farms, provided their battery packs could be changed over quickly. And since they can take off and land directly on the paddock, that means that hazards such as high voltage power lines should be far less of a problem. The whole concept could revolutionise crop spraying.

Geosat also have two fixed wing UAV designs, with wing spans of 3 metres and 3.8 metres. The smaller plane has maximum take-off weight of 24kg, 105km/h cruise speed, 145km/h maximum speed and a ceiling of 4000 metres. Its payload is 6kg and its twin-cylinder petrol engine has an endurance of four hours and a range of 350km. The larger model has a maximum take-off weight of 40kg and double

Power supplies on a heat soak cycle at Mean Well. Considering that each power supply is connected to a programmed electronic load, this room must have been using lots of energy, which would place a even bigger load on the air conditioning system. Funnily enough, the English sign above the doorway to this room was "Burning Room". There was no evidence of escaping smoke!



Ever wonder how those tiny DIP switches are assembled? Not with human hands, that's for sure. This automatic machine was thumping out 4-way DIP switches by the thousand! And there were many dozens of similar machines at this plant

the payload at 12kg. It also has double the endurance and its range is 800km. Both use a pusher propeller.

Good Will Instrument Company

This company's oscilloscopes would be familiar to many readers of SILICON CHIP although they are now branded as GW Instek; same company, different name (www.gwinstek.com). As well as oscilloscopes, they make a large range of other test equipment such as arbitrary function generators, spectrum analysers, signal generators, LCR meters, digital multimeters and so on. Again, their plant was large and modern but we did not get to the factory floor.

Mean Well group

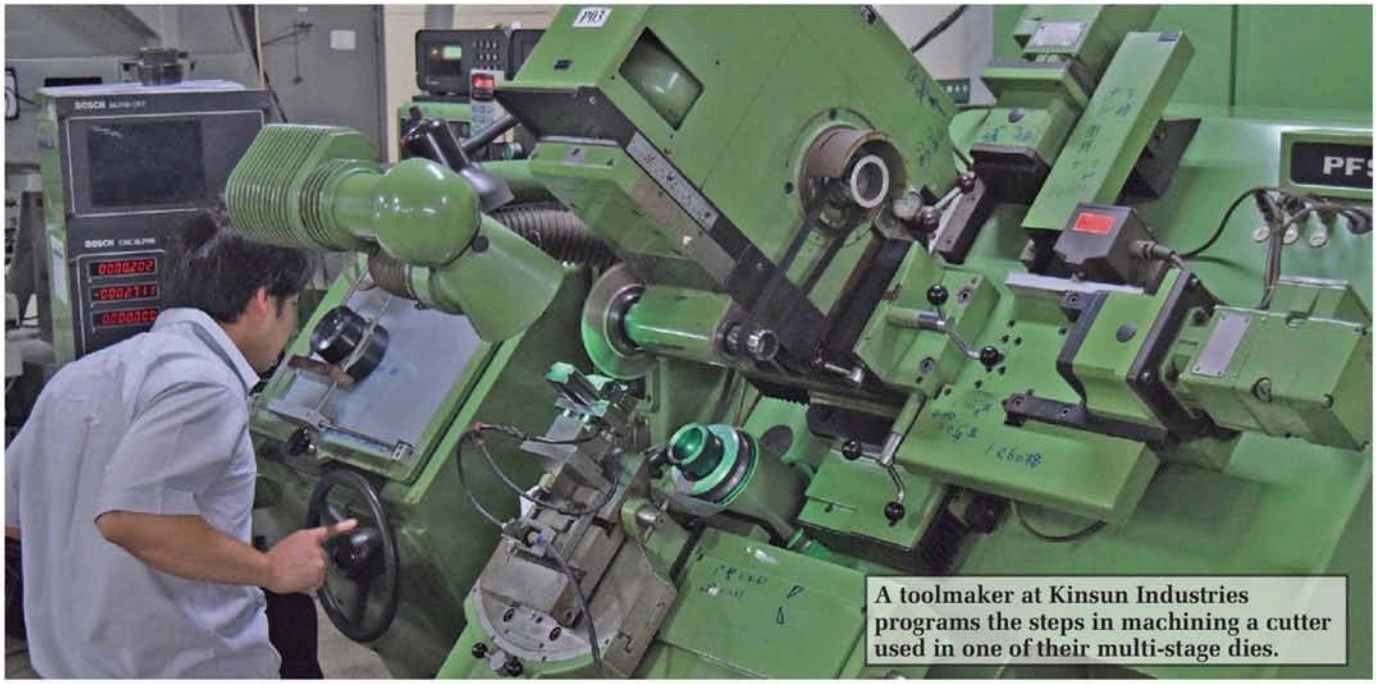
One Taiwanese electronics company which is certain to be well-known to many readers is the Mean Well group (www.meanwell.com) ranked sixth in the world as a manufacturer of switchmode power supplies, chargers and inverters.

They make a wide range of switchmode drivers for LED lighting of all types, including indoor, outdoor and street lighting. In fact, they manufacture an astonishingly wide range of supplies with power ratings up to 24kW – that's not a mistake! By contrast, their inverters range up to 5kW – quite modest in comparison.

Our party visited the headquarters plant in Taiwan but there are a number of other plants in Taiwan and China, with a total staff of about 2500. The production lines we saw were dedicated to relatively modest power supplies with ratings up several hundred watts.

The production lines were quite conventional in their layout and operation and would be typical of the lines in thousands of plants throughout the world. The PCBs use mainly SMDs (surface mount devices) for the smaller components and through-hole types for

This very large Regenerative Grid Simulator has a rating of 60kVA at up 300V in single or three phase in full 4-quadrant operation. It is designed for testing large grid-connected inverters.



A toolmaker at Kinsun Industries programs the steps in machining a cutter used in one of their multi-stage dies.

the power semiconductors, transformers, chokes, capacitors etc.

Every supply goes through a range of quality control tests before being packed and a sample of each production run goes through heat-soak tests, as depicted in one of the photos in this article.

A particularly interesting plant was that for Printec HT Electronics Corp. (www.printecht.com.tw). They make a large range of medical sensors and membrane switches, along with touch panels and flexible and rigid PCB assembles. This plant really gleamed, with large machines running continuously and many of the processes carried out in clean rooms.

Kinsun Industries Inc (www.kinsun.com) is a large manufacturer of all sorts of connectors and microwave antennas but I really did not expect to see much of interest. I was certainly wrong on that point.

They have so many processes for making connectors and they are pushing the technical boundaries in so many areas. For example, they are developing a range of connectors and microwave antennas to meet IP69K (IP stands for ingress protection or International Protection Marking), with potential applications for use in cars and high speed trains which will be subjected to rain storms at very high speeds.

Naturally they had a very comprehensive laboratory and testing installation, including a large anechoic chamber for testing microwave antennas. But it was the plant itself that really impressed with countless presses working at very high speeds thumping out streams of parts for tiny connector.

Interestingly, they made all their multi-stage dies in the same plant and they had very fancy machines to make the various cutting tools in those dies. One of those machines is pictured above.

All told, this was a whirlwind tour and really only a small glimpse of the huge range of manufacturing in Taiwan. Would I go back to see more of Taiwan and its high-tech plants? Definitely. SC

This is one of the many clean rooms at Printec HT Electronics Corp. This process was one of the stages for making membrane keyboards but they also produce a large range of disposable medical sensors.

SERVICEMAN'S LOG

The unfit Fitbit that was made fit

Dave Thompson*

I'm not really into gadgets such as smart watches, although the technology behind them is quite impressive. Recently though, I was given one to repair and it was quite a challenge to make the Fitbit fit again so that its owner could keep fit.

Items Covered This Month

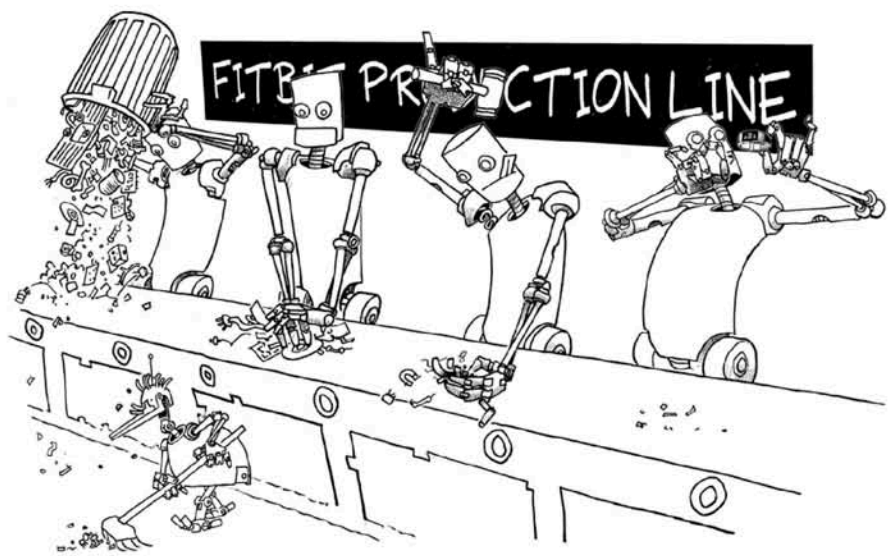
- Dave's Fitbit repair
- Church audio system repair
- Digitech ultrasonic cleaner
- Intermittent electrical fault in Holden Berlina

Many people these days are into gadgets. Actually, it's often not so much the gadgets themselves but the fact that they are connected to the internet that people find so appealing. Then there is this trend to wearable technology. A few years ago, we bought a watch just to tell the time. But these days, if one is up and coming, one must have a "smart" watch.

In addition, we have now been reintroduced to activity trackers. I say "reintroduced" because personal pedometers were all the rage among a certain set not that long ago, though like all exercise fad gadgets, they usually ended up gathering dust under the bed. However, the latest wearable exercise gadgets, typically futuristic-looking wristbands, measure all sorts of human activity, such as steps walked, sleep patterns, pulse rates and other crucial data we simply can't live without.

All this data can be uploaded via WiFi or GSM networks to the cloud where users can plot everything on impressive-looking graphs and spreadsheets in order to track their overall fitness, food intake, calories burnt, hours of sleep (and sometimes even stages of sleep) and other (more or less) useful stats. More importantly, "Generation Me" can share this information online with their friends, colleagues and competitors.

It's a great idea and also a great motivator, encouraging users get off their rear ends and go and crank out some more data to upload. So where's all this leading? Well, someone in this household (not me!) has bought herself a Fitbit, one of the fancier, wrist-borne activity trackers out there on the market.



~ THEY CRAM A LOT INTO THE SMALL CASE...

It's actually a very high-tech little gizmo, from its supple, purple, rubberised moulded body to its relatively small, high-resolution OLED display. Hers is a middle-of-the-range Fitbit and for what it cost to purchase, it should be flash!

Depending on the model, a Fitbit can include a heart rate monitor, an accelerometer, an altimeter, the usual clock/watch functions and a long-life lithium-polymer battery. And without trying to sound like an advertisement for the manufacturer, it really is a nifty little gadget and is easy to like. They cram a lot into the small case and while it's quite rugged, they can break down. Internet forums are awash with adopters complaining about this or that, as with any product, but as these devices usually cost a fair bit, users expect high-end results from them.

The display on the Fitbit is impressive. The resolution is fantastic and the figures extremely sharp and clear and easy to read, even in the brightest sunlight. They really are "cool" to use and work very well for counting steps, which is essentially what my wife bought hers for.

Fitbits are very reliable but as stated, they can have problems although it isn't always the electronics that fail. External parts can take a hammering and they need to be very hard-wearing to stand up to the punishment active users give them. However, this particular Fitbit was a bit unfit in some respects.

First, the material used in the strap

and body on my wife's version feels durable but splits very easily if bent the wrong way. Then there is what I consider to be a design flaw. In order to charge the Fitbit, it has to be connected via a short USB cable to a computer or to an optional plugpack power adapter. This cable has a proprietary fitting at the Fitbit end and this clicks solidly into place in the bottom of the unit, through a U-shaped hard plastic bracket that wraps around three sides of the case and hides the charging port inside.

The fourth "side" of the rectangle formed by this U-shaped strip is the display, with the rest of the case being there simply to hold that bit in the right place on the wrist for the sensor. And here's the design flaw; the other day, when Nina went to put the Fitbit on after charging it, that U-shaped bracket stayed behind, still securely clipped to the end of the charging lead. It had completely come away and when I looked closely at it under my microscope, it was easy to see why.

As I said, that bracket forms part of the "back" of the unit and it is held in place with four tiny plastic pillars. They are so thin and fragile, I was surprised that they'd lasted as long as they did! I know that everything has to be small in gadgets like this but given that the charging lead clips soundly into the charging slot in the plastic bracket, it wasn't going to take much to wrench the bracket from the body, as those tiny bits of plastic were all that held it on.

They could have made those plastic pillars bigger and still had room for other things. However, they really should have gone down the road that Apple went with their charging leads and used a magnet to hold it in. Or maybe the charging plug could have clipped into something built more securely into the body of the case, rather than just the hard plastic piece on the back.

It's a poor design in my opinion, considering everything else on the unit appears to be well thought-out and implemented.

The first job was to correctly refit the back to the body of the device. Just below where the bracket sits, there is a sensor. This is designed to sit on the top of the wrist and two bright-green LEDs flash away, monitoring the user's heart rate through the skin.

The problem was that the bracket had deformed slightly as it came away and when placed back into position, it didn't fit properly. The broken-off plastic pins didn't line up to where they should have and the sides had flared out, so that was going to be a problem.

Another tricky problem involved the button that controls the display functions. This is a separate assembly that passes through one side of the bracket and has to line up with a tiny microswitch beneath. This would have to be held in-place when the bracket was finally finagled into position.

I had to gently tweak and manipulate the bracket's plastic until it sat back where it should. This was a bit awkward but the plastic behaved itself and I eventually got it to sit in place. If the bracket had broken, it would have been game over.

The next challenge was to devise a method to securely hold the bracket in place. Gluing the original plastic pins was out of the question as there was virtually nothing to glue anything to. When a part has pins that break off, I can usually just glue them back into place and they are then strong enough to hold the part securely. However, with the Fitbit, the broken pins were so tiny that even if I could successfully glue them, the assembly was highly unlikely to be strong enough to withstand the stresses of the charging lead.

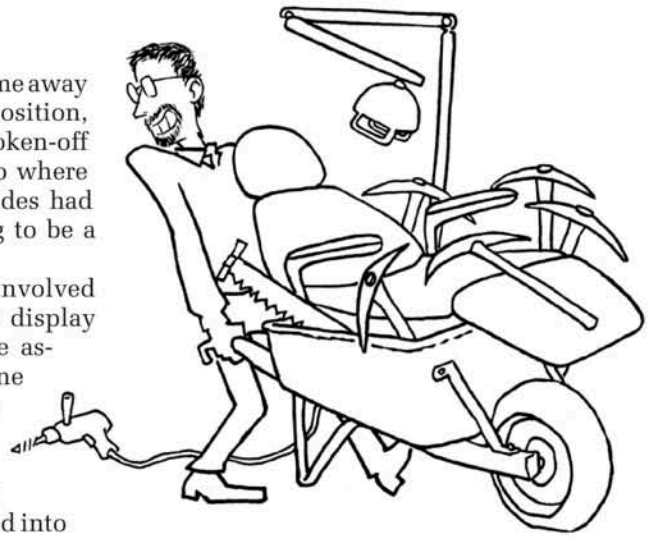
As a result, I initially considered simply gluing the edges of the bracket to the unit but again I doubted that it would work. None of the glues I had on-hand would adhere to the rubberised body and I wasn't sure if there was such a glue available anyway.

In the end, there was really only one thing I could do; screw the bracket back on. This involved some risk, as I wasn't absolutely sure whether or not there was anything vital to the operation of the device beneath the holes for the pins that originally held the back on. If I went poking about in there too deeply, I might hit something critical and that would surely be the end of the device.

Well, sometimes a serviceman has to make a bold decision and since there is next to zero information about the insides of these things anywhere on the web, I figured that I'd just have to take my chances. If I couldn't attach the bracket, the thing would be useless anyway.

I wasn't about to break out my taps and dies because the set I have didn't go anywhere near small enough for this job. Instead, my plan was to use a tiny drill bit to clear out as much of the remains of the pins as possible, then use one of my dental picks to get the rest out. I'd then be able to use tiny screws to self-tap into the holes left behind.

I was a little wary about using a drill but winding it by hand in my pin vice gave me enough control to ensure that I didn't go too deep. I also wrapped some tape around the bit to prevent it from going much deeper than the length of the screws I intended using. The four screws to be used were gleaned from my spares tray and once



Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in SILICON CHIP? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

No more crying in the chapel

It wasn't divine intervention that got the audio system in the church cry-room going again. Instead, rather than working in mysterious ways, B. C. of Dungog used old-fashioned, down-to-earth sleuthing to track the problem down. And he got the T-loop system (for those with hearing aids) working for good measure. Here's his story . . .

Our local church is celebrating its 100th anniversary this year and all stops are being pulled out to get the necessary preparations under way for this big event. One of my tasks was to investigate the lack of sound from the church's cry-room loudspeaker and from the T-loop system.

Before starting, I was given a brief run-down of the sound system upgrade that had been done a few years ago. This had involved the installation of a new mixer, a multi-core cable, a large stereo power amplifier and two large speakers. During a past building renovation, a cry-room (where crying children are taken) had been added inside the back corner of the church, along with a T-loop system for the hearing impaired.

Inside the cry-room, I found an old column speaker box mounted on the wall. This had been fitted with a 5-step attenuator control, while a figure-8 cable had been run back from the box to the sound system control cabinet.

Upon inspection of the sound system installation, there appeared to be only four microphones on the stage area (at the front of the church) plus an old Teac DVD player connected to a Yamaha 18/20-channel mixer. This meant that there was plenty of scope for future expansion! There were also a number of figure-8 speaker cables (entering via a flexible conduit through the floor), with most of these having being decommissioned during the last sound system upgrade.

I began by testing all these figure-8 cables with a multimeter and eventually found one that measured about 80Ω. To double check this, I disconnected one of the input wires on the back of the speaker level attenuator control in the cry-room and this confirmed that I had the correct cable.

I had also noticed a small transformer on the back of this plate. When I removed the speaker grille and the bottom speaker, I found another transformer underneath the inner bond filling. This had all been meant to be run on a 100V line public address system. No wonder the cry-room speaker cable had been left disconnected after the upgrade!

Initially, I considered rewiring the column speakers and fitting a rheostat to control the volume level but that would have meant tapping into an amplifier speaker output at the front of the church. It would also have been necessary to rewire the four column speakers to get the correct impedance.

When I returned to the sound system control cabinet, I noticed an old CS A600 series mixer-amplifier down on the bottom shelf. I pulled it out and found that it had a 100V line output as well as a normal 8Ω output. There was also an auxiliary input with its own level control but this had seized from lack of use over the years. Spraying some CRC 2-26 onto the seized shaft soon had this auxiliary input level control working again.

I now had to figure out how to connect a signal from the Yamaha mixer to the CS A600 amplifier's auxiliary input. A quick inspection of the mixer soon revealed unused left and right channel "record-out" sockets so the next step was to come up with a suitable patch lead.

Rummaging through the back of the cabinet soon turned up an unused 6.5mm jack plug and a spare stereo RCA-type audio lead. A pair of side-cutters, a hot soldering iron

held parts of a smart-phone together. I didn't measure them but they were just the right size to self-tap into the holes that had been cleared using the drill and pick.

Digressing slightly, I never leave my dentist's surgery these days without asking for any old tools they can spare. Many such implements are retired after a certain amount of time and service and while they're no longer any good for poking around inside someone's mouth, they are perfectly suitable for hobbyist use. They are cleaned in an autoclave and put aside for disposal but can come in handy for fine work and my dentist is always happy to let me rummage through their box of unserviceable tools.

I always grab a couple of handy-looking picks each time I go to my dentist and I then don't feel so bad when it comes to paying their bill.

Anyway, after clearing out the rivet holes, I used one of the screws as a tap and threaded each hole with it. It is always a bit nerve-wracking when brute-force tapping holes and in this case, I wasn't sure that the material would stand up to the process. My luck held though and the four holes were soon boasting nice new threads.

I went just a little deeper than I had to, taking into account the length of the screws and the thickness of the plastic they'd be going through. After all, I wanted to be sure I could tighten them down easily, to avoid breaking the plastic bracket.

Once that had been done, I drilled four new holes in the bracket itself, using the old broken pin stubs as a guide. I made the holes a neat fit for the screws and used a larger drill to carefully countersink the holes so that the screws wouldn't protrude and cause any discomfort on the wearer's wrist. It was then simply a matter of lining up the bracket, making sure the activity button was sitting in place, and gently driving the screws home.

This is where my precaution of pre-tapping the holes paid off. If the holes hadn't been pre-tapped, I would have had no idea as to how hard I was clamping down on the bracket. If I'd over-tightened the screws, I would have risked cracking the already-brittle plastic. And if they hadn't been tightened sufficiently, the bracket could potentially work its way loose again

By pre-tapping the holes, I could accurately judge just how much I needed to tighten them. As it turned out, the bracket is now held on much more tightly than the original ever was and

and some solder soon produced the required patch lead. This was connected and a test CD played through the church sound system. The auxiliary input level control on the old CS A600 was then adjusted so that a parent in the cry-room could adjust the speaker box over a useful range of volume using the attenuator control.

Now for the T-loop system. Also inside the cabinet was a rack-mount black box labelled "Printacall Hear All Powered Audio Induction Loop System". This had a volume level control on the back panel, while the front panel carried green and red LED indicators.

Sliding the box forward off its shelf revealed that the original figure-8 loop output cable was still connected but there was nothing connected to the input socket! No wonder it wasn't working; you didn't have to be a genius to figure that one out!

I found a suitable mono RCA-to-RCA audio lead in the back of the cabinet. This was then modified by cutting off the RCA plug at one end and wiring it instead to a 6.5mm jack plug. It was then just a matter of connecting it in place and adjusting the level control on the rear panel so that the red peak level indicator LED occasionally flashed briefly when the unit was being driven by the mixer.

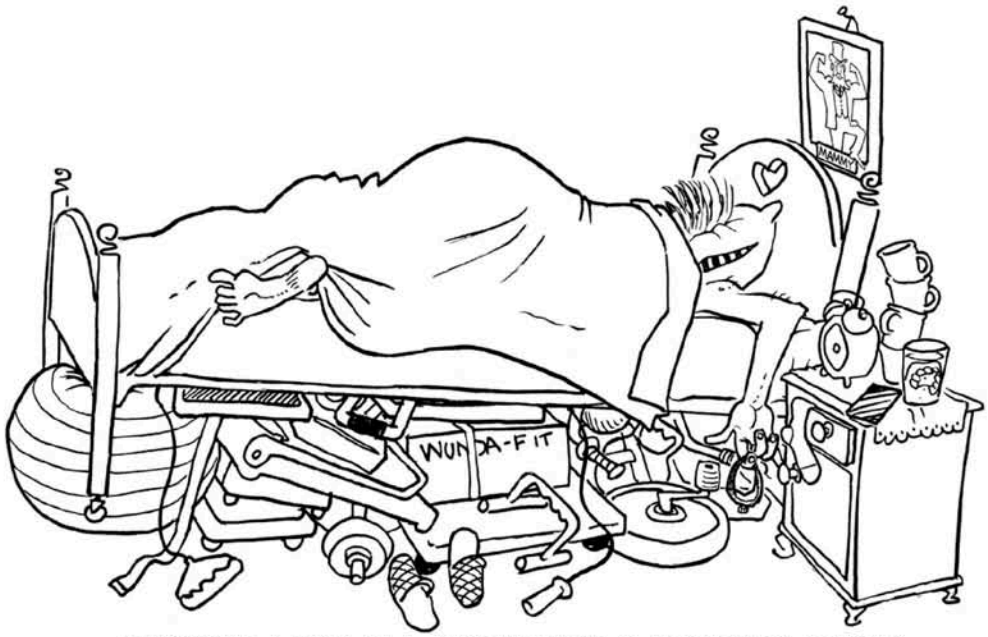
And that was it – the service is now available to those in the cry-room and those with hearing aids!

the repair should now last for the life of the device.

Digitech ultrasonic cleaner

Ultrasonic cleaners are great for cleaning parts – except when they don't work. B. B. of Northland, NZ seriously contemplated buying a new ultrasonic cleaner when his old one failed but eventually managed to get it going again . . .

My Digitech CT400D ultrasonic cleaner usually sits at the back of a top shelf in my workshop, its bright blue colour making it easy to find for those occasional cleaning jobs. It's easy to operate – just put the items to be cleaned into the tank along with a suitable liquid (a solvent or sometimes just water), the press either the 35W or 60W buttons. A 2-digit LED display then counts down from 99 seconds and then the ultrasonic cleaning action stops.



A job requiring its use came up recently and after putting the cleaning solvent and the bits to be cleaned into the tank, I plugged it in and tried to start it. There were no signs of life whatsoever, so I emptied it all out so that I could have a look inside.

After undoing three screws, the case came apart to reveal a small PCB beneath the display and the buttons, a round resonator glued to the bottom of the cleaning bath and a larger PCB on the base that does the "heavy lifting". There weren't all that many components so how hard could it be to fix?

Because it was completely lifeless, the first thing I looked at was the fuse. It had blown but not with any signs of violence. The first replacement fuse lasted until I pressed the 60W button, while a second fuse stayed intact when I pressed the 35W button but smoke soon started to appear from two 100Ω resistors. It was time to reach for my multimeter.

A quick check of the two BUT11AF TO-220 transistors gave low resistance readings and after removing them, I was able to confirm that they were both indeed faulty. I looked for other signs of heat and damage but found nothing, so I ordered replacement transistors and put the unit aside until the parts arrived.

When ordering replacement parts, it's often difficult to know just how many to get. Was the failure caused by these transistors? If so, only one pair would be needed; if not, how many would die (probably in twos) before the real cause of the problem was found? In this case, the transistors were cheap and are general-purpose enough to be useful for other jobs, so I ordered six.

With the new transistors fitted, I did a few more resistance checks and then plugged it in. The fuse held in both the 35W and 60W modes but the sound was wrong. I could hear some 100Hz hum but not the normal "fizzing" sound it makes when working. The display PCB was working OK and just controlled relays on the main PCB, so I was able to eliminate it from my investigation.

A schematic was looking like a useful thing to have in order to figure out what might have "killed" the transistors and what, in turn, their failure may have affected. Resorting to Google to find one gave me a sense of the likely configuration but nothing close enough to this unit to be worthwhile.

At this point, it was very tempting to simply buy a new unit rather than repair this one. Working on it "live" would mean dealing with mains voltages since there was no transformer, so I would need to take extra precautions and make sure that an oscilloscope was properly isolated. Alternatively, I could try working out the schematic by "reverse engineering" the unit.

Another option was to try working out what was wrong simply by checking the components one by one. And since there were not many of them, this became my preferred option, especially after I noticed a small hole in the coating of a 1Ω 1W resistor.

I checked this resistor and it meas-

Fault detector solves difficult intermittent in a Holden Berlina

by Dr Hugo Holden

This story relates to a car that was once owned by my wife. At the time, it was a near-new 1993 Holden Berlina which we purchased from a car yard in Auckland. It had a fuel-injected 4-cylinder Opel Vectra engine and was popular in NZ because of its good fuel economy.

It had done about 5000km when we purchased it and I wondered why the original owner had traded it in so soon and why the price seemed so reasonable. Well, we were about to find out.

After just a few days of driving it here and there, the engine suddenly cut out during a short trip. After the car had drifted to a halt, we attempted to restart it but it would simply turn over without even a hint that it would start. And then, after about 10 minutes, it suddenly started again and all appeared to be normal.

The car then ran normally for a few days before doing it again. This pattern of engine cut-outs was then repeated over the next two weeks and each time the engine could be restarted after waiting for somewhere between three and 10 minutes.

Alarmed by this, we took it back to the dealer and left it with their service department for several days. At the end of that time, they told me that they couldn't fault it and on top of that, no error messages had been recorded by the ECU.

They gave the car back but the fault quickly reappeared, the engine regularly cutting out although it ran faultlessly for up to three weeks at one stage. On delivering it back to the service department for a second time, I noticed as I gazed over the counter that its rego plate had been recorded in their service log book multiple times. I'd only brought the car in twice, so what was going on?

When I questioned them, I discovered that the original owner had brought it in with the same fault on multiple occasions, before giving up and abandoning it as a "lemon". They had even replaced the ECU (engine control unit) but to no avail.

I said to the service department manager "You sold my family this car knowing that it had an intermittent fault and that at any time it could stop on a motorway and place them in danger". He looked alarmed and became very defensive. "No I didn't, it wasn't me. It was those guys over in sales", he replied, as he gestured towards the showroom.

Giving it a go

I decided that since we liked the car otherwise, and since the dealer was incapable of fixing it, I would have a go at it myself. Thinking about the basics, an engine needs the FACTS to run: Fuel, Air, Compression, Timing and Spark. In this case, it was likely to be either a fuel or spark problem, as it was unlikely that the timing (either electronic or mechanical) would suddenly go haywire in a previously working engine and then suddenly fix itself again.

It was also unlikely to be an air-flow issue that was producing the abrupt engine stoppage although an air-flow meter fault is always a possibility. What's more, the ECU would have detected an out-of-range input from a faulty air-flow meter and thrown up a fault code. Since there were no recorded errors, an output device of one kind or another in the fuel or spark system was most likely intermittent but the problem was just how do you go about finding it?

The fact is, intermittent faults in an ECU-controlled engine can be a nightmare to track down. If anything stops the engine, the ECU detects that there is no engine rotation (because there is no signal from the engine rotation sensor) and it switches off the fuel pump, the injectors and the ignition system. So at that point, once the engine has stopped and you pop the bonnet to find the fault, there's no way of knowing which of the basic functions dropped out first to initiate the engine failure without fault codes and computer diagnostics.

What's more, those various subsystems cannot easily be checked in the case of an intermittent fault that sometimes occurs weeks apart. Because of this, I quickly realised that what was required was a monitoring system with latches to record which part of the system stopped first. In other words, I needed an "event recorder" with a memory.

Given that this was an urgent problem, I scrambled to the junk box to find some parts. I quickly grabbed some CMOS hex Schmitt trigger inverter ICs because they can be cobbled together in a myriad of ways and have a handy high input impedance. I also had some spare 4013 dual D-type CMOS flipflops and some diodes and LEDs.

There were several likely fault possibilities: (1) a fault in the output from the ECU to the fuel pump relay; (2) a faulty fuel pump relay output to the fuel pump; and (3) faulty ECU

ured much higher than its 1Ω markings indicated, so I replaced it with a 1.2Ω resistor, the closest 1W value I happened to have on hand. I then tested the unit again but there was no change; it still wasn't working.

As I continued component checking, I was contemplating what sort of test equipment I'd need to check the resonator and the coils when I found a second 1Ω resistor that had gone high. During this time, I was vaguely aware that our cat had come into the workshop and was sitting on the floor, not far from the bench. However, my awareness of his presence suddenly increased after I had replaced this resistor, the cat taking off in a blur as soon as I turned the cleaner on.

That was one bit of test equipment I didn't realise I had: an ultrasonic detector that runs on cat food!

Confirming the cat's diagnosis was easy because the fizzing sound was back. I then reassembled the unit, put some water in the tank and switched it on. It was now back to normal opera-

outputs causing either the fuel injectors or the ignition spark to stop. Each of those would require a monitoring line. Since the latter two rely on pulse signals, they would have to be monitored using pulse detector circuits.

Another possibility was that the engine rotation sensor itself was defective but I decided to hedge my bets on that one. As a result, I initially built a 4-input detector system. This was designed so that if an event occurred, then that channel would be latched and inhibit the other three recording channels. At the same time, one of four LEDs would light to indicate which channel was at fault.

The basic circuit I used is shown in the 4-Input Automotive Fault Recorder project overleaf on page 73. Rather than using more logic gates to inhibit the other channels, I simply used 10kΩ series resistors and clamping diodes which are driven by the Q-bar outputs of the 4013 flipflops. I didn't bother adding refinements like a zener diode on the 12V rail and cobbled it all together on protoboard, with light-duty wire-wrap connections.

I also used the same thin wire to connect to the fuel pump relay coil connection (at the output from the ECU) and to the fuel pump relay output (at the pump itself). This was done simply by pushing the wire into the spade connectors and the same was done for the connection to one of the fuel injectors. Spark monitoring was achieved by wrapping five turns of wire around the outer surface of a spark plug cable, to make a "gimmick" capacitor.

I had previously realised that I should ideally be monitoring circuit currents instead of voltages. That's because the correct voltage can be present at a given point but there's no current due to an open circuit condition. In fact, I had this up my sleeve as "plan B" if monitoring the voltages didn't bear any fruit.

I also realised that if worse came to worst, I would have to fit a pressure sensor to the injector's fuel rail but I hoped that I wouldn't have to go that far. For the time being, I figured that voltage monitoring was the easiest approach.

Anyway, I fitted the assembly to the car, ran the wires through to the engine compartment and taped the horrible looking mess with its four LEDs to the dashboard. I then started the engine, pressed the reset button and found that all LEDs were off, as they should be.

Nailing the fault

Nothing happened during the first few days of driving and then suddenly, on the fourth day, the engine cut out. I looked at the panel and saw that LED2 had lit, indicating that although the fuel pump relay was on (LED1 off), the output from this relay had vanished. After a 5-minute delay, the car started again and I rushed back home and unplugged the fuel pump relay for inspection.

It turned out to be a Bosch unit with a grey plastic case. Its base was sealed onto the case with silicone rubber and I removed this before prising the inner assembly out.

Once it was out, I found that it mainly consisted of a relay bobbin assembly mounted on a small PCB. This PCB also carried a diode that looked like a 1N4004. It was in series with the coil, presumably to prevent the relay from turning on with reverse polarity applied.

The wire enamel on the coil was discoloured, indicating that the relay had been running quite hot. I took a closer look at the PCB and the answer was staring me right in the face; a 360° crack around the soldering on one of the relay coil's connector pins. As it heated up, it was expanding and going open circuit and it was probably being affected by vibration as well.

Once it had gone open circuit, it then cooled down again until it eventually remade the connection and reapplied power to the fuel pump. This explained why the car could be restarted after a short wait.

I measured the resistance of the coil and, using the formula $P = V^2/R$, calculated that the relay coil was dissipating about 4W, assuming a supply voltage of 14V (as it typically was). That explained why the coil wire looked as though it had been overheated.

Fractured solder joints like this appear to be more common when there are a combination of factors: (1) significant heating and cooling cycles of the pin which can harden and crystallise the solder; (2) a PCB hole which is larger than necessary for the pin passing through it; (3) a fairly sparse or thin sheet of solder bridging the gap between the pin and the PCB pad; (4) the PCB hole not plated-through; and (5) physical forces due to a weighty object (in this case the relay).

Resoldering the faulty joint and covering the crack with a generous amount of solder cured the problem once and for all and the car ran without any further engine problems.

I returned to the dealership a few weeks later and explained to the service manager how I was able to find the fault with my home-made fault recorder. He seemed to be astonished at the notion of a fault recorder and had never before heard of using such a technique to track down an intermittent fault.

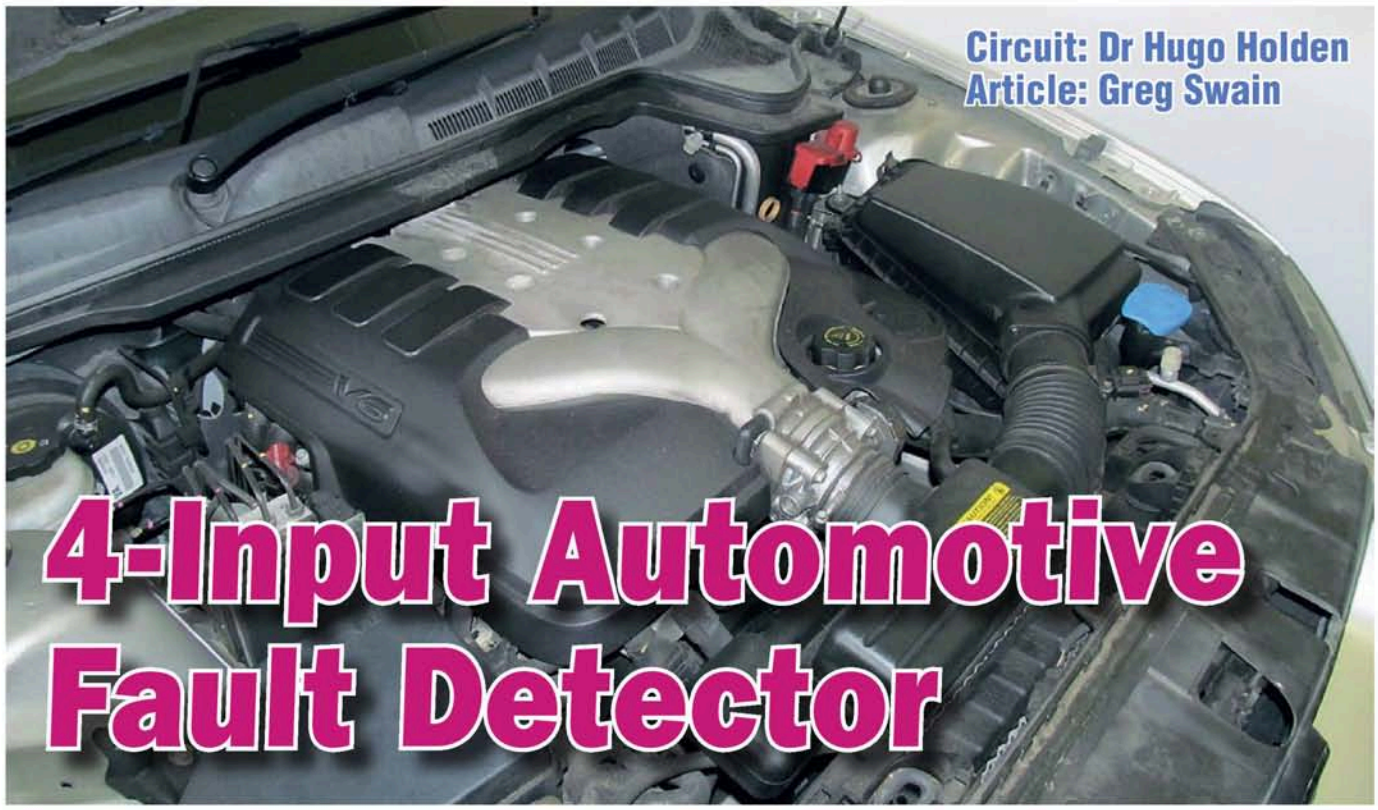
At the end of the conversation, he offered me a new relay for free so I took it to keep as a spare. However, the fact remains that the dealership should never have sold us that car without first fixing this potentially dangerous fault.

tion, with the familiar ripples on the surface changing pattern between the 35W and 60W modes.

So, as it turned out it, I only needed a multimeter to identify the faulty parts. The components markings were readable and the replacements readily available, so it wasn't too much of a hassle to repair the unit. It would have been interesting if I'd had to check the resonator though but fortunately I didn't have to.

Looking at the schematics I found on-line, it appears that the two BUT-11AF transistors operate in a high-power oscillator. A ferrite-core coil and a capacitor are tuned to the same frequency as the resonator, allowing self-oscillation with low-gain, high-power transistors. The ultrasonic signal is superimposed on 100Hz of unfiltered, rectified mains to include both high and low frequencies in the cleaning "signal".

As for the cat, he spends a lot of time at the other end of the house whenever the unit is operating. SC



Circuit: Dr Hugo Holden
Article: Greg Swain

4-Input Automotive Fault Detector

Got a car engine that cuts out suddenly and unexpectedly? Does the car have an intermittent bug or gremlin in its electrical system? This 4-Input Automotive Fault recorder is just the shot for tracking down an elusive fault that's missed by the onboard diagnostics.

ONE OF OUR regular contributors, Dr Hugo Holden, recently sent in a Serviceman's Log story describing how he tracked down an elusive, intermittent engine fault in a 1993 Holden Berlina. At unpredictable times, after it had been running for a while, the car's engine would suddenly cut out and could only be restarted again after about 10 minutes. The dealer he bought the car from hadn't been able to fix it, so he devised a clever method of solving the problem himself.

The car's ECU (engine control unit) and ignition timing pick-up had already been replaced by the dealer, so that eliminated those two possibilities. So was it a fuel pump problem, a sudden failure of the injector pulses or were the HT pulses to the spark plugs going AWOL? Or was there some other obscure bug? Once the engine had cut out, the ECU shut everything down so it was impossible to tell.

Hugo Holden's initial approach was to assume that it was an electrical problem and so he designed a simple 4-Input Fault Detector with indicator LEDs. This circuit was then used to monitor four control signals: (1) the ECU's output to the fuel pump relay; (2) the fuel pump relay's output (ie, the voltage driving the fuel pump); (3) fuel injector drive pulses and (4) the HT ignition pulses to one of the spark plugs.

While ever these circuits all functioned normally, the detector's four indicator LEDs were all off. However, if one circuit developed a fault, its corresponding indicator LED would light and (simultaneously) the other three would be "locked out", so that they would not light as the engine was quitting. And that would be the "gotcha" moment, as the lit LED would indicate the system that brought it to a halt.

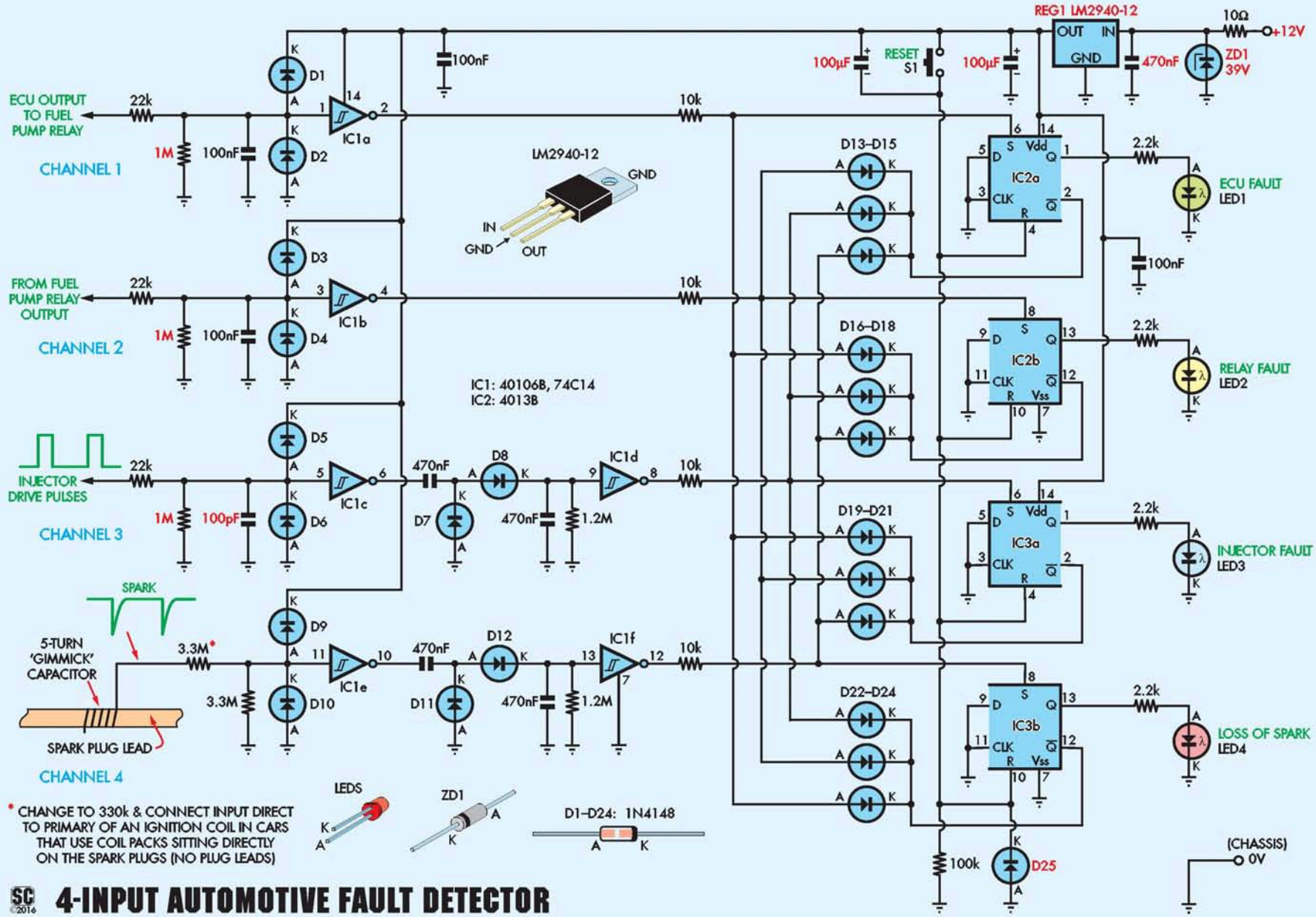
If you haven't read Dr Holden's story in this month's Serviceman's Log then take a look at it now (see "Fault Detector Solves Difficult Intermittent In A Holden Berlina"). It gives the background and describes how he tracked down an elusive (and potentially dangerous) fault in his car. We won't spoil the mystery by telling you what it was here; it's all in the Serviceman's Log.

Along with the story, Dr Holden also sent in the full circuit details of his fault detector. We liked the idea so much that we decided to design a PCB for it, so that anyone can easily build it.

Circuit details

Fig.1 shows the circuit devised by Dr Holden, with just a few minor enhancements (the parts labelled in red). First, we've added more protection to the supply line in the form of zener diode ZD1 and an LM2940-12 automotive voltage regulator (REG1). The addition of REG1 also allowed us to reduce the 1000µF filter capacitor originally used to 100µF.

Other changes to the original circuit include the addition of 1MΩ pull-down resistors on three of the inputs (channels 1-3), to ensure that the device would "notice" if any of the signals went momentarily open-circuit, and a 100pF filter capacitor across the injector pulse input circuit to filter any spikes which may be induced by the ignition system. We also added a 100µF capacitor across switch S1, to



SC 2016 4-INPUT AUTOMOTIVE FAULT DETECTOR

Fig.1: the circuit uses a 40106B hex Schmitt trigger IC to monitor four inputs: the ECU's output to the fuel pump relay, the fuel pump relay output, a set of injector pulses and the HT pulses to one spark plug. If an input signal ceases, the Set input of its associated 4013B flipflop is pulsed high and its output LED lights. At the same time, diodes D13-D24 ensure that the Set inputs of the remaining flipflops are latched low, so that their LEDs stay off.

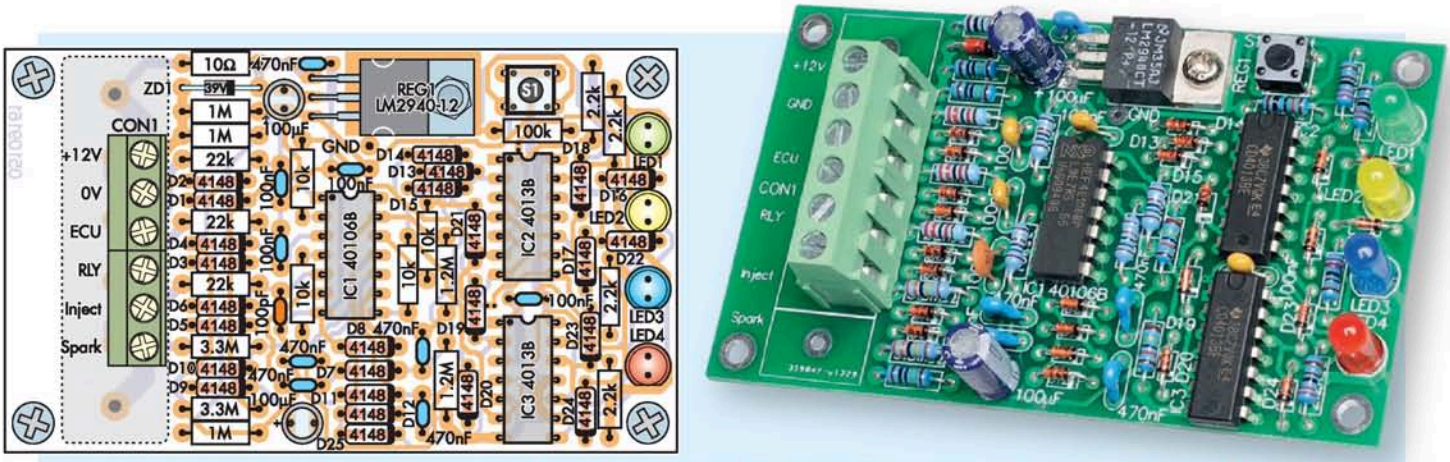


Fig.2: follow this parts layout diagram and the photo to build the PCB. Be careful not to get the ICs mixed up and note that the LEDs should be mounted horizontally if you intend installing the unit in a box (see text).

provide an automatic power-on reset.

Previously, it was necessary to press S1 to reset the circuit after power-on, to ensure that all LEDs were initially off. This meant that the unit had to be mounted inside the cabin, so that the reset switch could be reached. Including the automatic power-on reset means that the circuit can now be mounted under the bonnet; there's no longer any need to run wires through the firewall and into the cabin. With this arrangement, it's simply a matter of opening the bonnet after the engine cuts out to see which LED is lit.

As shown in Fig.1, the circuit uses just three ICs: a 40106B hex Schmitt trigger inverter (IC1) and two 4013B dual-D flipflops (IC2 & IC3). LEDs1-4 are the output status indicators.

IC2a, IC2b, IC3a and IC3b all have their D (data) and CLK (clock) inputs connected to ground so that they operate as Set/Reset (or RS) flipflops. Their reset (R) pins are connected in parallel and are normally pulled low via a 100kΩ resistor. When power is applied, these reset pins are all briefly pulled high via the 100µF capacitor (or when S1 is pressed), and so the flipflops are all reset, with their Q outputs low and Q-bar outputs high. This ensures that LEDs1-4 are all initially off.

Moving now to the inputs, channel 1 monitors the ECU's drive to the fuel pump relay, while channel 2 monitors the line from the fuel pump relay to the pump itself. These two channels are identical, so we'll just concentrate on channel 1.

When the engine is running, the pump relay signal from the ECU will be high (ie, at +12V). This signal is filtered and fed to pin 1 of Schmitt trigger inverter IC1a. IC1a's pin 2 output will thus be low and so flipflop IC2a will remain in the reset state, with its Q output low and LED1 off.

However, if the ECU's output suddenly fails, pin 1 of IC1a switches low (aided by a 1MΩ pull-down resistor) and so its pin 2 output goes high. This pulls IC2a's Set input (pin 6) high and forces its outputs to the set state, with Q high and Q-bar low. As a result, LED1 lights to indicate an ECU fault.

At the same time, the signal to the Set inputs of the other three flipflops are pulled low by IC2a's Q-bar output via diodes D13, D14 & D15. This ensures that these flipflops remain reset and so LEDs2-4 stay off. This effectively prevents these LEDs from turning on when their respective channel inputs go low as the engine stops.

This means that only the LED associated with the fault that initiated the engine shut-down can light. The others are effectively locked out. The same scheme is used for the other three flipflops, utilising diodes D16-D24.

Diodes D1 & D2 are included to protect IC1a by clamping the input signal to the supply rails.

Channel 2 operates in exactly the same manner. It turns on LED2 if the output from the fuel pump relay suddenly fails while the engine is running.

Injector & ignition pulses

Channel 3 is used to monitor the drive pulses to one of the fuel injectors. First, the signal is filtered and inverted by IC1c. IC1c then drives a charge pump circuit consisting of diodes D7 & D8 and two 470nF capacitors.

When injector pulses are present, the square-wave signal couples through the series 470nF capacitor, charging the subsequent capacitor via D8 and

Injector & Ignition Pulses Can Cease During Engine Over-Run

This Event Recorder was initially developed to troubleshoot a problem in a 1993 vehicle. However, most modern cars switch off the injectors and the ignition when the engine is in over-run and the throttle is closed. This typically occurs during a downhill run and is done to save fuel.

This condition would cause either LED3 or LED4 in the Fault Detector to light, so you need to keep this in mind when using this unit. In fact, it may be necessary to mount the reset switch inside the cabin so that the unit can be manually reset if this occurs.

In some cases, it may be possible to alter the driving style to prevent this from happening. Normally, the injectors switch off only if the engine speed exceeds about 1500RPM and the throttle is closed.

Finally, note that many modern cars don't have spark-plug leads. Instead, they use an ignition coil pack which is fitted directly to the spark-plugs.

If so, it may be possible to detect ignition pulses in a lead that connects to the primary of one of the coils (eg, near the connector). In that case, the input is connected directly to the primary lead (instead of via a gimmick capacitor) and the input resistor is changed to 330kΩ (see Fig.1).

Low-Side Switching

On many cars, the ECU's output to the fuel pump relay will employ low-side switching, ie, it switches the relay coil's negative lead. Similarly, the relay's output may switch the negative side of the fuel pump.

If so, an additional inverter stage will be required after IC1a and/or IC1b. This can be done by piggy-backing another 40106B (with all but its supply pins splayed out) on top of IC1. The relevant PCB tracks can then be cut and the connections run using short lengths of wire.

so pin 9 of IC1d is high and its output remains low. IC3a is thus held in the reset state and LED3 is off. However, if the injector pulses suddenly cease, the 470nF capacitor discharges through its parallel 1.2MΩ resistor (in around 500ms) and IC1d's pin 8 pulls the Set input of IC3a high. IC3a then turns on LED3 to indicate an injector fault.

The other three LEDs are latched off in exactly the same manner as before.

Channel 4 monitors the HT pulses to one of the spark plugs. As shown, the HT pulses are picked up by winding five turns of wire around one of the plug leads to form a "gimmick" capacitor. The resulting capacitively-induced pulses are then fed to pin 11 of IC1e.

IC1e drives a charge pump circuit which operates in exactly the same manner as for channel 3. If the ignition pulses suddenly cease, IC1f's output switches high and drives LED4 via flipflop IC3b.

Building it

All parts are mounted on a double-sided PCB coded 05109161 and measuring 89 x 53.5mm. Fig.2 shows the parts layout on the board.

Begin the assembly by installing the resistors, diodes and zener diodes. Pushbutton switch S1 and the three ICs can then be installed, followed by the capacitors. Don't get the ICs mixed up; they all have 14 pins but IC1 is a 40106B while IC2 & IC3 are both 4013B types. Make sure that they are all orientated correctly.

Regulator REG1 can now go in. It's installed flat on the PCB with its leads bent down through 90° some 8mm from its body so that they go through their respective holes. Fasten REG1's metal tab to the PCB using an M3 x 6mm machine screw, washer and nut before soldering its leads.

LEDs1-4 are next. Take care with their orientation; the flat (K) side of each LED body goes towards the bottom edge of the PCB.

If you going to mount the unit in a box, you should install the four indicator LEDs horizontally. That's done by bending each LED's leads down through 90° about 2mm from its body, then soldering it in place so that it sits slightly proud of the board's top surface. The LEDs can then protrude through holes drilled in the side of the box. In this case, you should also use a chassis-mounted momentary pushbutton switch in place of reset switch S1, in case you need to manually reset the unit once it's in place.

Connector CON1 is fitted last. You can either use a 6-way PCB-mount terminal barrier strip or two 3-way screw terminal blocks. The barrier strip makes it somewhat easier to terminate leads but will be too tall to fit inside the specified case (in which case screw terminal blocks will have to be used).

If you're using the specified case, the PCB is mounted using the tapped spacers and machine screws specified in the parts list. While not strictly necessary, we've also listed parts so that you can make a connection between the pad marked GND on the PCB and the earthed metal case, ie, using a solder lug, machine screw, washer, nut, length of wire and a PCB stake.

The six wires going to CON1 can pass through a cable gland fitted on the end of the box.

Fitting it

Mounting the unit in the engine bay will usually be the best approach. In most cars, this will give easy access to the main fusebox, so that you can access power and the fuel pump relay. It also makes it easy to make the connections to one of the spark leads and a fuel injector signal lead.

Be sure to install any wiring in a professional manner, so that you don't compromise the car's existing wiring and cause further problems. For example, if you need to penetrate any insulation to make a connection, make sure the connection is waterproof so that you don't have problems in wet or humid weather and so that corrosion will not be encouraged.

Note that this circuit may not work in all respects with all cars. There are lots of different vehicle wiring configurations, so check carefully before fitting this unit.

Note also that the outputs won't latch until about 10s after powering on or resetting the unit, due to the 100µF capacitor on the reset line. SC

Parts List

1 double-sided PCB, code 05109161, 89 x 53.5mm
1 6-way PCB-mount terminal barrier, 8.25mm-spacing* (CON1, Altronics P2106) ***OR***
2 3-way screw terminal blocks, 6mm spacing (CON1)
1 4-pin tactile pushbutton switch (S1)
1 M3 x 6mm machine screw & nut

Semiconductors
1 40106B or 74C14 hex schmitt trigger (IC1)
2 4013B dual flip flops (IC2,IC3)
1 LM2940-12 automotive low-dropout regulator (REG1)
1 green 5mm LED (LED1)
1 yellow 5mm LED (LED2)
1 blue 5mm LED (LED3)
1 red 5mm LED (LED4)
1 39V 1W zener diode (ZD1)
25 1N4148 diodes (D1-D25)

Capacitors
2 100µF 16V electrolytic
5 470nF multi-layer ceramic
4 100nF ceramic disc or multi-layer ceramic
1 100pF ceramic disc

Resistors (all 0.25W, 1%)

2 3.3MΩ	3 22kΩ
2 1.2MΩ	4 10kΩ
3 1MΩ	4 2.2kΩ
1 100kΩ	1 10Ω

Additional parts for box mounting
1 diecast aluminium case, 111 x 60 x 30mm (Jaycar HB5062)
1 cable gland to suit 3-6mm cable
8 M3 x 5mm machine screws
1 M3 x 10mm machine screw, star washer and nut
1 solder lug
1 1mm diameter PCB stake
4 M3 x 6.3mm tapped Nylon spacers
1 short length green hook-up wire

* Note: terminal barrier is too tall to fit in the specified diecast case – see text

- 5-inch touch screen
- Even more I/O pins
- Expansion slots
- USB & serial interfaces
- PS/2 keyboard socket

Micromite Plus Explore 100

Pt.1: By Geoff Graham

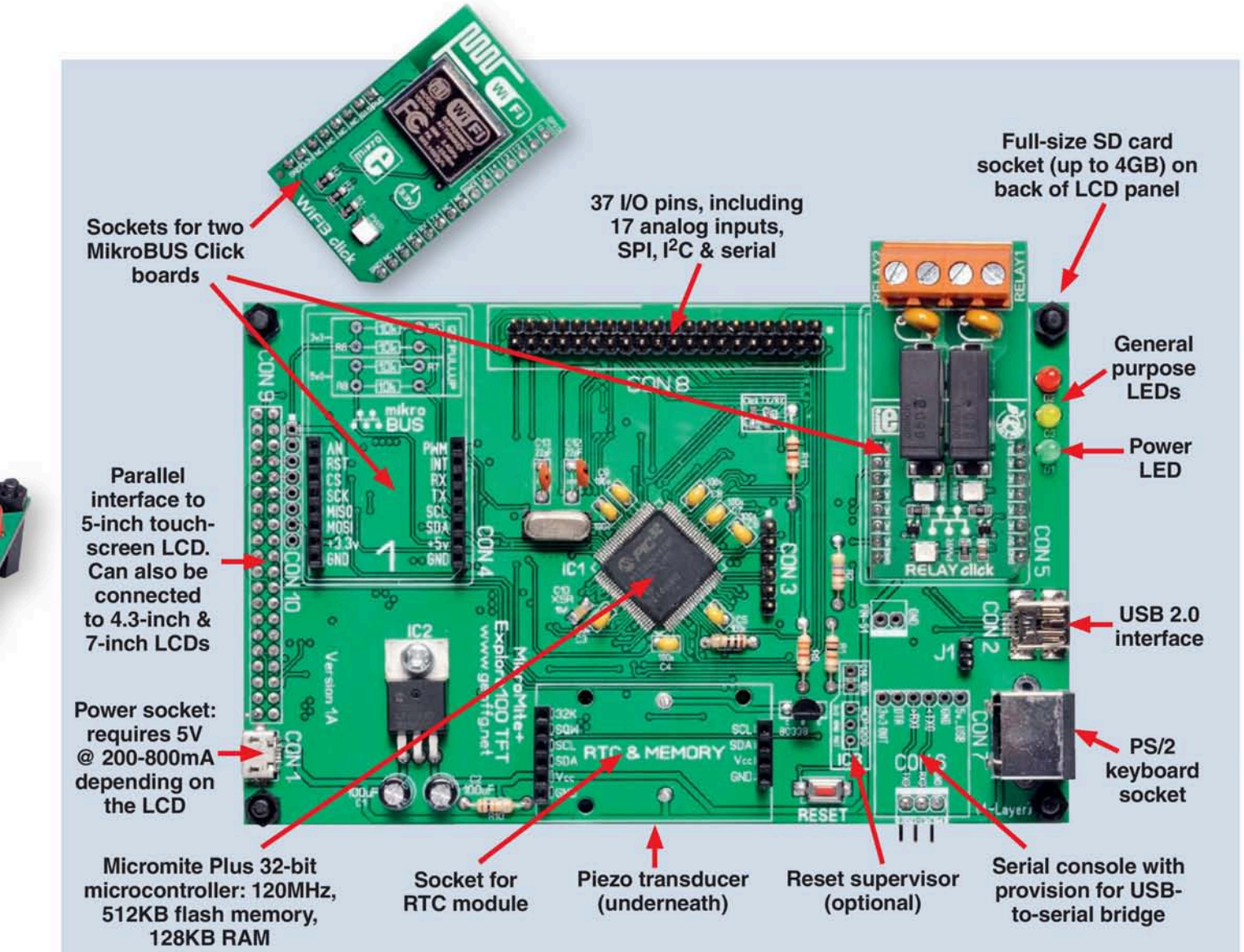
The Explore 100 expands on the Micromite Plus Explore 64 described last month, adding more I/O pins, two slots for mikroBUS Click expansion boards, provision for a Real Time Clock (RTC), USB-to-serial adaptors and a PS/2 keyboard socket. Perhaps most importantly, it connects directly to (and mounts on) a 5-inch touchscreen for stunning graphics. It can be used as a fully integrated computer or as an advanced embedded controller.

THE EXPLORE 100 combines a high-performance microcontroller, programmed with the Micromite Plus firmware, with a large and colourful display panel that can draw graphics and sophisticated on-screen controls such as radio buttons, check boxes, spin boxes and more.

The Explore 100 PCB is designed to match the dimensions of a standard 5-inch touch-sensitive LCD panel so that when the two are mated, they make a slim "sandwich". This neat display/controller package can be treated as a single intelligent device and mounted in a control panel or on the front of an enclosure where it could display data and accept control input via the touch-sensitive screen.

At the core of the Explore series is the Micromite Plus, a fast microcontroller with a built-in BASIC interpreter and drivers for touch-sensitive LCD displays, PS/2 keyboards, SD/microSD cards and a host of special devices such as infrared remote controls and temperature sensors.

This project has a dual personality. Firstly, it makes an ideal controller/interface for anything that needs an in-



This photo summarises the features and capabilities of the Explore 100. These features include the 32-bit microcontroller with its in-built BASIC interpreter, 37 input/output pins for controlling external devices, two sockets for MikroElektronika click boards, a USB 2.0 interface, a connector for a PS/2 keyboard and on-board sockets for a super-accurate real time clock (RTC) module and a USB-to-serial converter.

put system and control display panel. Examples include a sophisticated irrigation controller, an easy-to-use security system, a computer-controlled lathe and a general industrial controller.

The Explore 100 can be mounted in a control panel where it can display graphs and numbers while accepting input commands on its touch-sensitive screen. It has 37 spare input/output lines which can be used for monitoring voltages, currents, switch closures, etc and can control external devices by closing relays, illuminating LEDs etc.

Secondly, the Explore 100 can act as a completely self-contained computer, similar to the Tandy TRS-80, Commodore 64 or Apple II of yesteryear. It's a bit like the popular Maximite featured in SILICON CHIP in the March-May 2011 and September & October 2012 issues – but much more powerful! With its colourful LCD screen and PS/2 keyboard interface, you can learn to program it in the easy-to-use BASIC language and make use of the SD card facility to save and load programs and data.

Using BASIC, you can draw graphic objects on the LCD panel, including lines, circles and boxes, as well as turn individual pixels on (or off) in any one of 16 million colours. You can use it for educating your children, tracking astronomical objects, writing games or just exploring a fun, easy-to-use computer system.

LCD touch-screen panel

The Explore 100 can use all the different LCD panels that were described in the Explore 64 article last month, ranging from a tiny 1.44-inch display up to a monster 8-inch touchscreen with a resolution of 800x480 pixels. But it's specifically designed to work with panels that use the SSD1963 display controller, ranging from 4.3 inches (diagonal) to 8 inches. The SSD1963 has a parallel interface, allowing the Micromite Plus to transfer data at high speed, so these screens are ideal for displaying complex graphics.

Compatible displays can be found on eBay for US$25 to US$60. In addition to the display itself, they feature a touch-sensitive screen surface and a full-size SD card socket, both of which are fully supported by the Micromite Plus.

Explore 100: Features & Specifications

- Mates with a 5-inch SSD1963-based touch-sensitive LCD with 800 x 480 pixels @ 16 million colours (4.3, 7 & 8-inch panels are also suitable)
- 32-bit CPU running at 120MHz with 512KB of flash memory (58KB available for programs) and 128KB RAM (52KB available)
- In-built Microsoft-compatible BASIC interpreter with 64-bit integer, floating point and string variables, arrays and user-defined subroutines and functions
- 37 I/O pins independently configurable as digital inputs or outputs; 17 can be used as analog inputs
- Two MikroElektronika Click board sockets. Almost 200 Click boards are available including Ethernet, WiFi, Bluetooth, relay outputs, current measuring and more
- USB 2.0 serial interface for program editing and upload/download from a PC
- Supports microSD and SD cards up to 64GB
- On-board sockets for accurate real-time clock and USB-to-serial converter
- PS/2 keyboard connector allows the Explore 100 to can act as a fully self-contained computer and development system
- In-built graphics commands, including pixel, line, circle and box
- Six in-built fonts plus many more fonts that can be embedded in a program
- Advanced graphics commands include on-screen keyboards, buttons, switches, check boxes and radio buttons
- Standard Micromite features, including many communications protocols with SPI, I^2C and 1-Wire plus in-built commands to directly interface with IR remote controls, temperature sensors and other devices
- PWM or SERVO outputs and special embedded controller features such as variable CPU speed, sleep, watchdog timer and automatic start and run
- Runs from 5V DC at up to 750mA (depending on LCD panel and brightness)

The mounting holes and physical dimensions of the Explore 100's PCB are designed to match the 5-inch display version. The Explore 100 is secured to the back of the display using four spacers, one at each corner, to create a single rigid assembly.

Input/output pins

The Explore 100 has a 40-pin general purpose input/output (GPIO) connector. Various pins on this connector can be configured as analog or digital inputs, digital outputs, frequency inputs, PWM outputs and much more. Also available on this connector are three high-speed serial ports (RS-232 TTL), an I^2C interface and an SPI interface.

In total, this connector has 37 I/O pins plus three pins for supplying power (ground, +3.3V and +5V). All of the I/O pins can act as either digital inputs or outputs, while 17 of them can also be used for measuring analog voltages. The GPIO connector can be linked to another PCB via a 40-way ribbon cable or connected directly to another PCB which can piggyback onto the Explore 100, making a 3-board sandwich.

If you want to develop additional circuitry on a breadboard, you can purchase adapter boards that take a 40-way cable and spread the signal lines out to 0.1-inch pins that can plug into a standard solderless breadboard. They are intended for use with the Raspberry Pi but they work well with the Explore 100 (all except a few I/O pins are available).

The Explore 100 uses a 100-pin Microchip PIC-32MX470 microcontroller programmed with the MMBasic firmware. The pins on this surface-mount package have a 0.5mm spacing which can be soldered with a standard temperature-controlled soldering iron. Photo courtesy Microchip.

mikroBUS Click boards

The Explore 100 has two sockets for mikroBUS Click boards, which is a standard developed by the European company MikroElektronika. At last count, there were almost 200 of these little boards providing just about any function that you can think of, including an Ethernet interface, Bluetooth, WiFi and GPS (plus many more). They are ideal for adding a specific function to the Explore 100 without the hassle of building it yourself.

For example, by plugging in the TextToSpeech Click board, you can make voice announcements from your BASIC program and by using one of the WiFi boards, your program can generate a web page for access via the internet. Another example is the RF Meter click board which can be used to measure RF power over a frequency range of 1MHz to 8GHz with a 60dB dynamic range.

The MikroElektronika catalog also includes an adaptor Click board which allows you to use the range of 10-pin Olimex UEXT Modules and these add a further 100 or so modules to the available selection. You can find compatible Click boards by searching the internet for "click board" and UEXT modules by searching for "UEXT".

A self-contained computer

Perhaps the most exciting feature of the Explore 100 is that it makes an excellent self-contained computer. It starts up instantly, contains its own programming language and it's just a matter of plugging in a keyboard to start experimenting.

If this sounds familiar, it might be because you've read the articles on (or perhaps even built) the Maximite and the Colour Maximite, featured in Silicon Chip in March-May 2011 and September-October 2012. The Explore 100 acts very much the same as these; the difference is that it uses a full colour LCD panel (rather than eight colours on a bulky VGA monitor) and runs twice as fast with four times the memory.

The keyboard interface will work with a standard PS/2 keyboard and has support for the number pad, function and editing keys. The keyboard is essential if you are using the Explore 100 as a general-purpose, self-contained computer and is also useful when the Explore 100 is mounted in a control panel. In that case, you can plug in a keyboard and make changes to the program without pulling out your laptop.

An important part of a self-contained computer is the program editor. The full-screen editor used in the Micromite Plus is quite advanced and allows you to scroll through your program, search for text and cut or copy text to the clipboard and paste it somewhere else. It also displays your program on the LCD panel with colour coding, so that keywords are in one colour, comments in another and so on.

The best part of the editor is that the run/edit/run cycle is very fast. When you have edited your program, you only need to press the F2 key on the keyboard to automatically save and run it. If your program contains an error, the BASIC interpreter will stop and display an error message.

You can then press the F4 key to take you back into the editor, with the cursor positioned at the line which halted the program. After you have corrected the fault, pressing F2 will save and run the program again. It doesn't get much easier than this.

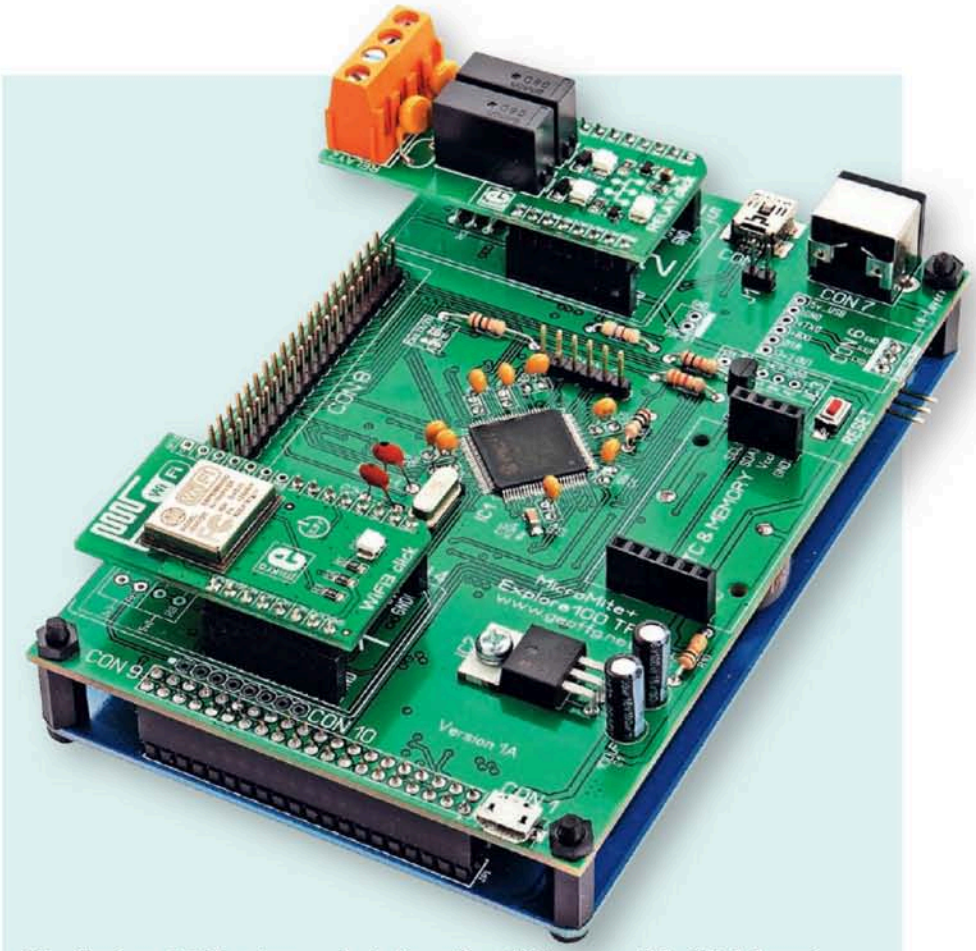
You can save programs on an SD (or microSD) card for safekeeping, although this is not strictly necessary as the program in the Micromite Plus is held in non-volatile flash memory, which means that it will not be lost when the power is turned off. However, using an SD card allows you to have multiple programs which you can load, edit and save at will.

As a self-contained computer, the Explore 100 still has access to all the features of the Micromite Plus, including a USB (serial) interface, multiple fonts, an extensive suite of graphics commands and powerful input/output facilities. In addition, the two Click board sockets allow you to quickly add extra functions to expand the computer's capability. For example, you could plug in an RS-232 Click board and use the Explore 100 to control an item of test equipment.

Display size

When you are using the Explore 100 as a self-contained computer, the larger the screen size the better. We recommend the 5-inch display as it works well and matches the size of the Explore 100 board. However, if you opt for a larger screen, the characters are correspondingly larger and easier to read.

Clearly, the 7-inch display will be easier to read than the 5-inch display and the 8-inch display easier again (available from EastRising at www.buydisplay.com). **Note though that the EastRising panel uses non-standard interface connector pin-outs so you must use point-to-point wiring between the Explore 100 PCB and the LCD panel.**



The Explore 100 has two sockets for mikroBUS-compatible Click boards. This is a standard developed by the European company MikroElektronika and covers a wide range of plug-in modules, including Ethernet, Bluetooth, WiFi and GPS modules – perfect for adding extra functions to the Explore 100. A WiFi board and a relay board are shown connected here

Incidentally, the LCD panels do not cost a huge amount so you could always purchase both a 5-inch and a 7-inch panel and see which one better suits your requirements. That will also give you a back-up panel which could come in handy during testing.

Console connections

On the lower righthand corner of the Explore 100's PCB are the serial console and USB console connectors. The console is an important part of the Micromite Plus as this is how you configure and program it using a larger computer, running a terminal emulator. The serial console and USB console work the same, so you can use either as the console or even both at the same time.

In the Explore 64 article last month, we discussed when and why a serial console is handy (rather than just using the USB console). Basically it's because the serial interface will remain working whenever the Micromite Plus is restarted, unlike the USB interface which will lose its connection on every restart.

Depending on what type of development work you are doing, you may need to reset the Micromite Plus regularly and this is where the serial console is handy. If you are using the Explore 100 as a self-contained computer, this is less of an issue and generally the in-built USB interface will be fine.

Serial port driver

If you are using a version of Windows earlier than Windows 10, you must install the SILICON CHIP USB Serial Port Driver on your PC (available for download from the SILICON CHIP website) before you can use the USB console. The full instructions are in-

cluded with this driver. The Micromite Plus uses the standard CDC protocol and drivers are built into the Mac and Linux operating systems (and also into Windows 10).

The PCB also features a footprint to suit a CP2102-based USB-to-serial converter which gives the Explore 100 a USB console that will not reset when the Micromite is reset. These converters are available from the SILICON CHIP Online Shop – see **www.siliconchip.com.au/Shop/7/3543**

The CP2102-based USB-to-serial converter needs a 6-pin header soldered to the appropriate pins and then it can be simply plugged into its position on the PCB. There are no special configuration commands that need to be run, as MMBasic defaults to using a serial console unless told otherwise.

Other features

The Explore 100 is designed to use the full-sized SD card socket which is mounted on all compatible LCD display panels. However, if you are mounting the Explore 100 on the back of the 5-inch display as intended, the SD card will stick out the top.

This could be a bit awkward in some situations so the SILICON CHIP version of the Explore 100 PCB also has an on-board microSD card socket (the original version has an SD card header only – see panel). You can use either, or both. The two sockets share the same SPI serial interface but have separate CS (card select) and CD (card detect) lines.

Currently, the Micromite Plus has to be rebooted to change the SD card pins so you can't switch between the sockets at will, although this might change in future versions

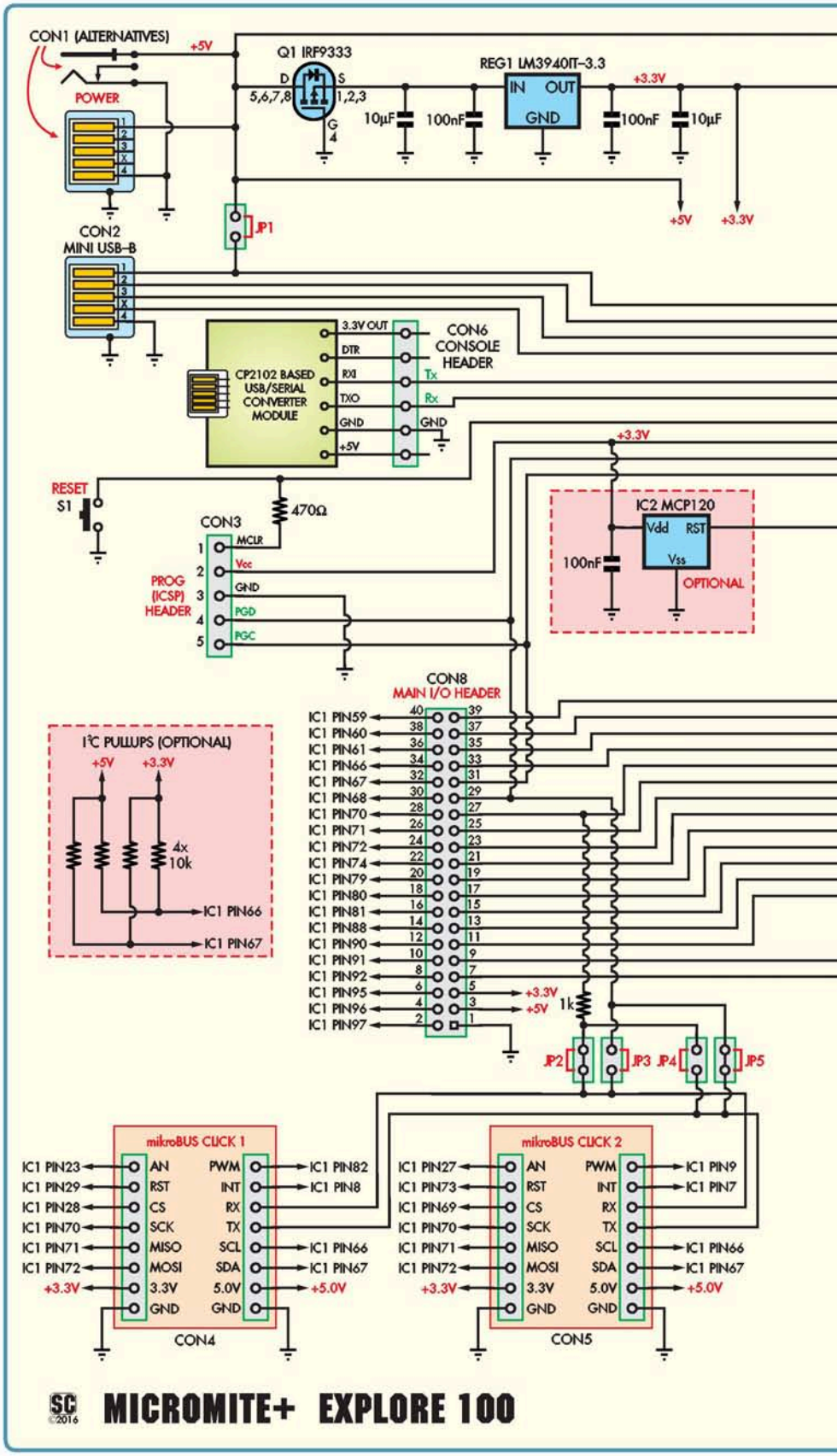
You can open files on either card to read or write data from within the BASIC program. All files created are compatible with standard desktop computers so you can use the SD card to log data for later analysis.

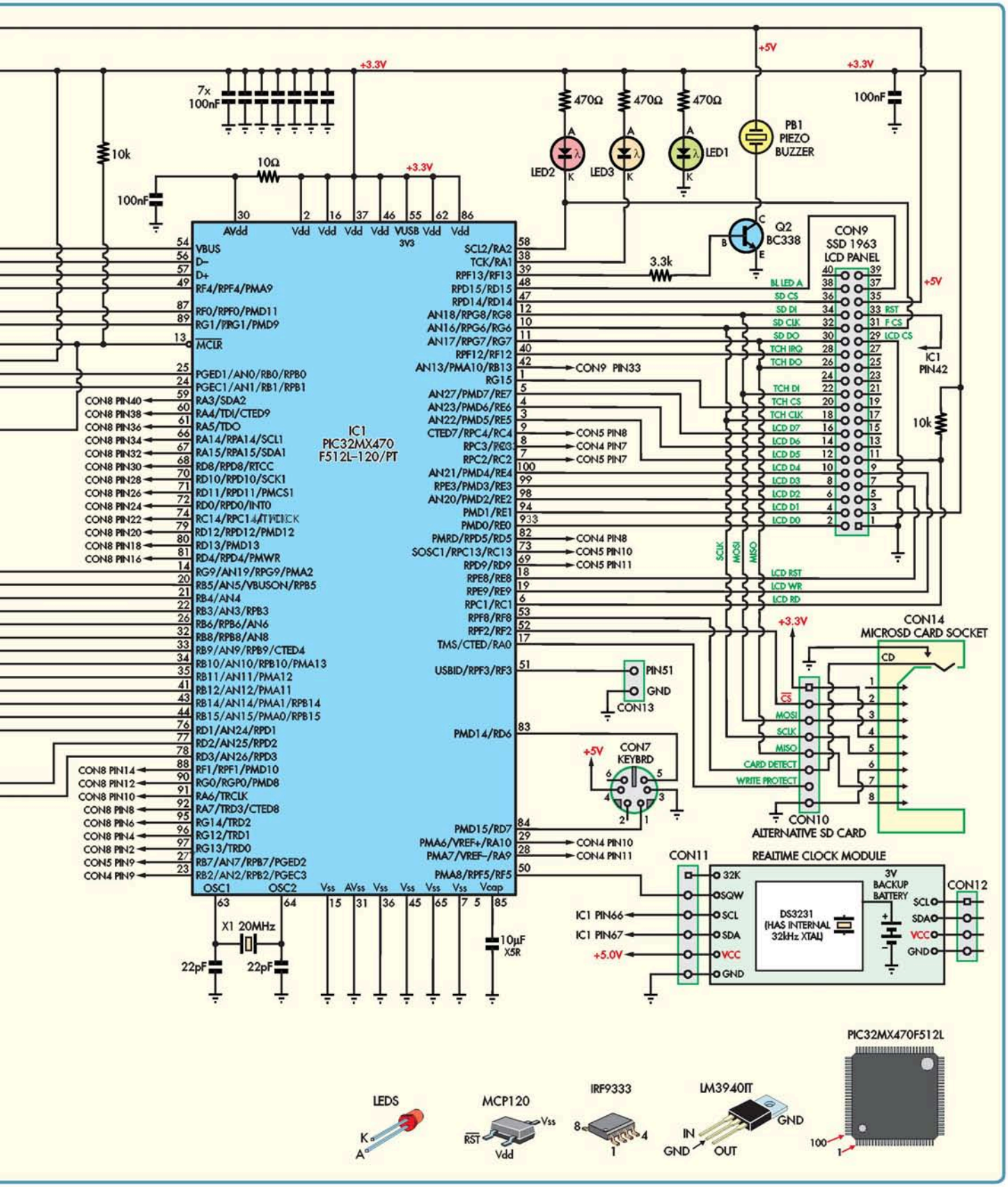
You could also mount a second SD card socket somewhere else using the alternate SD card connector (CON10), which is wired in parallel with the onboard microSD card socket.

MCP120 reset supervisor

The PCB also has provision for installing a Microchip MCP120 supervisor device. This is optional and if installed, will monitor the main 3.3V power rail and reset the Micromite Plus if the voltage drops below a critical level (around 2.7V for the specified part).

Basically, the MCP120 is designed to provide an extra level of protection in an industrial environment where power brownouts and electrical noise could cause a microcontroller like the





Micromite Plus to run amok.

Yet another feature is a piezo buzzer. This is mounted underneath the board and produces a "click" sound for au-

Fig.1: the complete circuit of the Explore 100 module. It's based on a 100-pin PIC32MX470F512L microcontroller IC1, running the Micromite Plus firmware. Many of the pins on IC1 are routed to various connectors for GPIO, the LCD panel, Click boards and other modules. The remaining circuitry consists of a power supply (based on REG1) and an optional supply supervisor (IC2).

Explore 100 Parts List

1 4-layer PCB, code 07109161, 135mm x 85mm
1 5-inch LCD panel with SSD1963 controller, touch interface and SD card socket ***OR***
1 4.3-inch, 7-inch or 8-inch LCD panel with SSD1963 controller
1 5V DC 1A+ regulated DC power supply with 2.1/2.5mm inner diameter DC connector (centre pin positive) or micro-USB plug
1 PCB-mount DC socket, 2.1/2.5mm inner diameter, to suit power supply (CON1a; eg, Altronics P0620) ***OR***
1 SMD micro-USB Type B socket (CON1b)
1 SMD mini USB Type B socket (CON2; Altronics P1308 or similar)
4 8-pin, two 6-pin and one 4-pin female header sockets (CON4-CON6,CON11a,CON11b) ***OR***
2 40-pin or 1 50-pin female header socket cut into sections (as above)
1 40-pin or 50-pin male header, 2.54mm pitch, snapped into two 2-pin, one 6-pin & one 8-pin sections (JP1, JP2, CON3, CON10)
1 3-pin right-angle header, 2.54mm pitch (CON6)
1 6-pin PCB-mount mini DIN socket (CON7; Altronics P1106 or similar)
1 dual-row 40-pin header, 2.54mm pitch (CON8)
1 dual-row 40-pin female header, 2.54mm pitch, or dual-row 40-pin male header and matching IDC cable (CON9; see text)
1 microSD card socket (CON12, optional; Altronics P5717 or similar)
2 shorting blocks (JP1,JP2)
1 20MHz crystal, low profile (X1)
1 23mm buzzer (Altronics S6108) or 14mm buzzer (Altronics S6104 or S6105) (PB1; see text)
1 tactile pushbutton switch, four pin, through hole (S1)
4 M3 x 12mm tapped spacers & 8 M3 x 6mm machine screws ***OR***
4 M3 x 12mm untapped spacers & 4 x M3 x 16mm machine screws plus 4 x M3 nuts (LCD mounting)
1 M3 x 6mm machine screw with matching nut (for REG1)

Semiconductors

1 PIC32MX470F512L-120/PF (120MHz) ***OR*** PIC32MX470F512L-I/PF (100MHz) in 100-pin TQFP package, programmed with Micromite Plus firmware (IC1)
1 MCP120-270GI/TO reset supervisor, TO-92 package (IC2, optional – see text)
1 LM3940IT-3.3 regulator, TO-220 package (REG1)
1 IRF9333PbF Mosfet (Q1, optional – see text)
1 BC338 transistor, TO-92 (Q2)
1 green 3mm LED (LED1)
1 red 3mm LED (LED2)
1 yellow 3mm LED (LED3)

Capacitors

2 100µF 16V electrolytic
1 10µF SMD ceramic, 3216/1206 package, X5R or X7R dielectric
11 100nF ceramic disc or multi-layer ceramic
2 22pF NP0 ceramic disc

Resistors (0.25W, 5%)

2 10kΩ
1 3.3kΩ
1 1kΩ
4 470Ω
1 10Ω

Where To Buy Parts

A PCB and a short form kit with the four surface-mount components already soldered in place is available from Graeme Rixon – see www.rictech.nz/micromite-products

Silicon Chip can also supply the PCB, programmed microcontroller, RTC module and USB-to-serial adaptor as separate items, as well as a complete kit without the LCD – see our Online Shop for details.

Two PCB Versions

As noted in the text, the Explore 100 PCB was designed by Graeme Rixon of Dunedin, NZ – see www.rictech.nz/micromite-products

The PCB sold by Silicon Chip is virtually identical to this board, the main difference being that we've added an on-board micro-SD card socket (CON14). It's linked directly to the original SD card header on the PCB (CON10).

The Silicon Chip PCB can also accept either a DC power socket or a micro-USB socket for CON1, whereas the alternative PCB now has provision for a DC socket only (in place of the original micro-USB socket).

Finally, note that the PCB shown in the photos is a prototype and the final version differs in a few respects. In particular, the earlier version did not include Mosfet Q1 in the supply line to provide protection against reversed supply polarity.

dible feedback when a GUI element on the screen is activated.

The PCB also has three indicator LEDs. The green LED is the power indicator, while the red and yellow LEDs are general-purpose indicators which can be controlled by the BASIC program to signify some status.

Circuit details

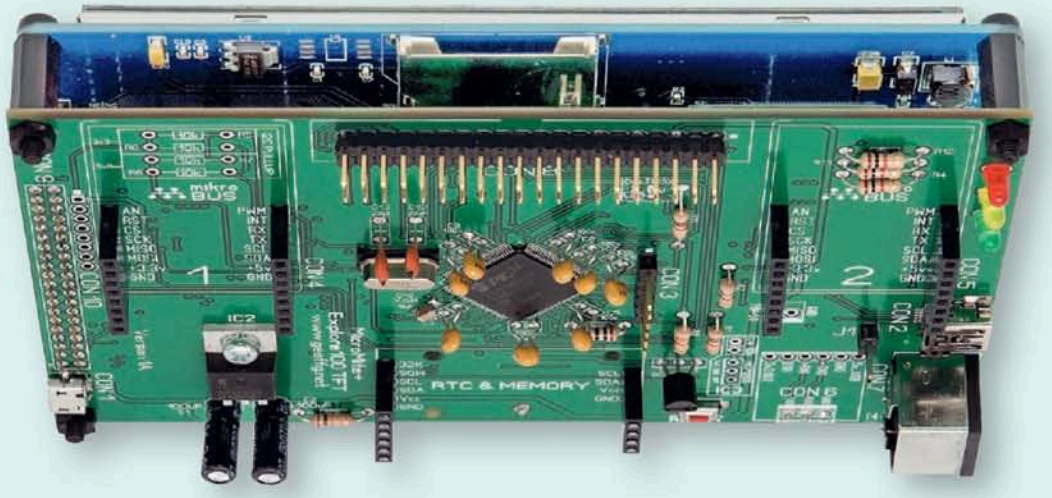
Referring to Fig.1, you can see that the Explore 100 is mostly a carrier for the 100-pin PIC32 chip (programmed with the Micromite Plus firmware) and the various connectors. Other than the voltage regulator and two transistors, there are no other active devices.

The power input is protected from reverse polarity by Q1 which is a P-channel Mosfet. This is optional and the board is designed so that you can run a blob of solder over two pads and dispense with the Mosfet. Having said that, it doesn't cost much and has little effect on the circuit other than to protect it against damage, so we'd recommend you fit it.

The input 5V is routed to a number of locations, including the Click board sockets, the real-time clock module (RTC), keyboard and I/O connector (CON8). It is also routed to the LCD connector (CON9) as some displays, particularly the 7-inch versions, use this for powering the backlight.

REG1 is a low-dropout linear regulator which provides 3.3V to the PIC32 (Micromite Plus), the Click boards, I/O connector and the LCD panel. It is mounted on a large area of copper on the PCB which acts as a heatsink. As a result, it only gets slightly warm, even at full load.

As with most designs involving a microcontroller, there are 100nF capac-



The Explore 100 is designed to work with LCD panels that use the SSD1963 display controller which range in size from 4.3 inches (diagonal) to 8 inches. The mounting holes and physical dimensions of the PCB are designed to match the 5-inch version of this display. The PCB mounts onto the back of the display with four spacers, one at each corner, which creates a single rigid assembly.

itors across all supply lines to reduce voltage variations when pulses of current are drawn. These are through-hole components; the only surface-mount passive component is the 10µF multilayer ceramic capacitor for the PIC32's internal 1.8V core regulator (connected to pin 85). The part used should have an X5R or X7R dielectric.

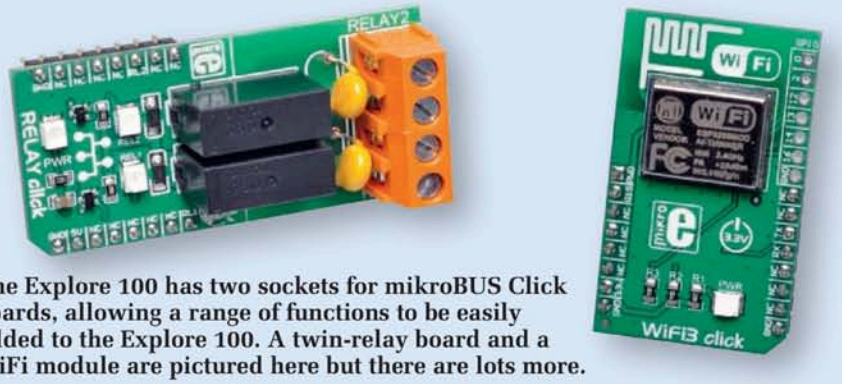
The circuit shows pin 51 from IC1 connected to a 2-pin header. This I/O pin was spare and rather than ignore it, we routed it to a header so that it can be used for something if needed. The circuit also shows four 10kΩ resistors marked "I²C pull-ups". These provide the option of pulling up the I²C signal lines to either 3.3V or 5V. Normally they are not required as most modules using I²C already have these resistors onboard.

Jumper JP1 allows 5V from USB connector CON2 to supply power to the Explore 100. For normal use, a jumper should not be fitted as it could cause the 5V supply from CON1 to back-feed the USB host (a no-no!). However, if you want the USB connector to power the board, you can short JP1 but then you must not use CON1.

Power supply

The photos show an early version of the prototype which used a micro-USB connector for the power input. The final PCB has the option of using either a micro-USB or a standard DC power connector. It also has provision for the previously-described optional Mosfet to protect against accidental power polarity reversal.

The most convenient power source for the Explore 100 is a 5V regulated plugpack. **Make sure that you do not use one of the older transformer-style plugpacks which can easily deliver 8V or more when unloaded, even though they are labelled as 5V. An over-voltage of that magnitude will destroy IC2, the keyboard and any attached Click boards.**



The Explore 100 has two sockets for mikroBUS Click boards, allowing a range of functions to be easily added to the Explore 100. A twin-relay board and a WiFi module are pictured here but there are lots more.

The current drawn by the Explore 100 depends on the LCD panel used. With a standard 5-inch panel it will be about 500mA, not including the power drawn by the Click boards or I/O pins. With a 7-inch LCD, it will be about 750mA with the same provisos.

PCB design

The Explore 100 is built on a four-layer PCB which, like the Explore 64 described last month, was designed by Silicon Chip reader Graeme Rixon of Dunedin, New Zealand. Normally you would expect something of this complexity to fit on a double-sided board but because the 100-pin Micromite Plus in the centre connects to almost every other place on the board, a 4-layer design was required.

A 4-layer PCB essentially consists of two thin double-sided PCBs glued in a sandwich, with a dielectric (insulator) in between. The layers are connected by drilled and plated vias which pass through all four layers.

Note that some 4-layer boards have vias which don't go all the way through. In fact, in some cases, they only pass through internal layers ("blind vias"), so they are not visible from the outside of the board. Our design doesn't use any such vias, though.

We're using the outer (top and bottom) layers for signal and power routing and ground planes, with the two internal layers for additional signal routing only. Typically, for a four or 6-layer PCB, the internal layers are used for power and ground planes and the outer layers for signal routing but this is a signal-heavy board so a different scheme was used.

Next month

That's all we have space for this month. Next month, we'll give the full assembly details for the Explore 100, describe the display mounting and describe the setting-up, testing and fault-finding procedures. SC

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Based on the Currawong amp (K 5528) with a new low voltage DC power supply. Very low distortion for a valve pre-amp with very high SNR of 105dB. Easy to build, with the preamp & power supply on one board. Includes 12VDC 1A plug pack. *Clear acrylic box available to suit (K 5193 $34.95). Uses Electro-Harmonix 12AX7.

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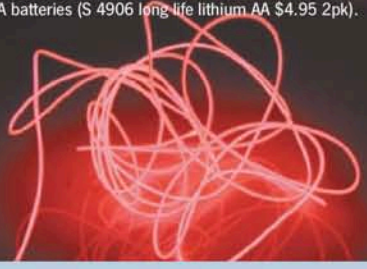

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W 2765

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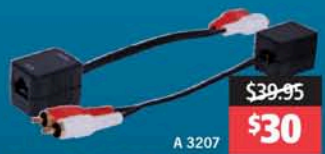
Hook up the output of a TV to your favourite RCA stereo amp. Includes plugpack.



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A 3207

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CLEARANCE!

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GREAT VALUE POWER ACCESSORIES

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NEW! **$44.95**

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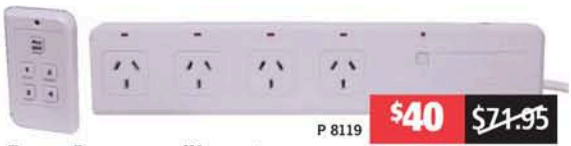

P 8119 ~~$71.95~~ **$40**

Turn appliances on or off by remote.

Control each socket from a single remote. Reduce power consumption by turning off idle appliances around the home or office. 50m range.

Keeps your rack tidy!

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Pins	Part	Normally	NOW
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Touchscreen Appliance E

Part 2 –

By JIM ROWE & NICHOLAS VINEN

Last month we introduced our new Appliance Energy Meter. It uses a 2.8-inch touchscreen to display energy usage data and has handy features such as cost calculation based on time-of-day tariffs, graphing and logging. This second instalment will take you through the process of building the PCBs and assembling the whole unit, as well as describe some of the interesting features of the software.

The Appliance Energy Meter consists of two modules. The larger PCB hosts the custom circuitry for this project while the smaller one is used to build the Micromite LCD BackPack, which provides all the control, display and user interaction functions.

The BackPack module and main PCB fit into a UB1 jiffy box along with a mains fuseholder and two cable glands to secure the mains wiring.

The February 2016 article introducing the LCD BackPack has the full construction details, although it's pretty self-explanatory.

We can supply a kit with all the parts for the BackPack (including some of the mounting hardware you'll need later), and you just fit the kit components to the PCB where indicated on the silkscreen.

Once you've assembled the BackPack, including the display, check that it works if you can but don't go any further. We'll program it after building the main PCB. If you're programming the PIC32 chip on the BackPack PCB yourself, now would be a good time to do that.

SMD parts

The main PCB has just three SMD ICs plus about 20 passive components. Refer to the PCB overlay and wiring

nergy Meter

We've had to make a minor circuit change since the first article on the Appliance Energy Meter was published last month.

We've added a 100nF capacitor between the Earth terminal on CON8 and the VREF pin (pin 10) of IC2. This reduces the effect of noise from switching regulator REG1 on the operation of the analog-to-digital converter.

As a result of this change, we've decided not to supply the RevF PCB as mentioned in the parts list last month, which needed an adaptor board, and instead wait for the RevG boards to arrive which incorporate both changes and thus do not require the extra assembly work.

diagram, Fig.3. IC2 has a relatively fine pitch while IC3 and IC4 are easier to solder. So fit IC2 first. This can be done with a standard soldering iron. The only extra tools you need are a good light, some flux paste (available from Jaycar, among other stores), solder wick, flux cleaner (eg, methylated spirits or pure isopropyl alcohol) and some sort of magnifier for checking the solder joints.

There are a few different techniques but unless you happen to have a hot air or infrared reflow set-up, they're pretty similar. Start by depositing a little solder on one of the corner pads – try not to get any on any of the other pads. Then you have two options, depending on which you think will be easier.

You can either place the LTC1863 in position, check that all its pins are properly aligned over its pads and that pin 1 (indicated with a dot or divot) is at upper left as marked on the PCB and shown in Fig.3. Then, while gently pressing the IC down onto the PCB, heat the solder on the pad that you deposited earlier so that the associated pin sinks down into it. Then re-check the positioning and solder the diagonally opposite pin.

Alternatively, you can position the IC next to its pads with pin 1 in the correct orientation and, while heating the solder on that one pad, slide it into position using tweezers or a couple of fingers. Then check that all the pins are correctly located over the associated pads. If not, reheat that solder joint and gently nudge it into position before soldering the diagonally opposite pin.

Either way, you should now have the IC located properly and pinned down so it's just a matter of soldering the remaining pins. You can attempt to do this one at a time, by first applying flux along all the pins and then touching the tip of the soldering iron, loaded with a little solder, onto the very ends of the PCB pads. Alternatively, simply solder the pins two or three at a time, then apply flux paste and use solder wick to remove the excess solder.

Regardless of which method you use, make sure to refresh the solder on those first two pins and use the flux paste and solder wick to clear any bridges between pins. Finally, clean off the flux residue using your solvent of choice and a lint-free cloth, then inspect the IC under a bright light and high magnification to ensure all solder joints are good. If any do not look 100% or you find any bridges, apply some flux and heat (and if necessary, solder wick) until it all looks good.

Then solder IC3 and IC4 using the same technique although you should find them significantly easier due to

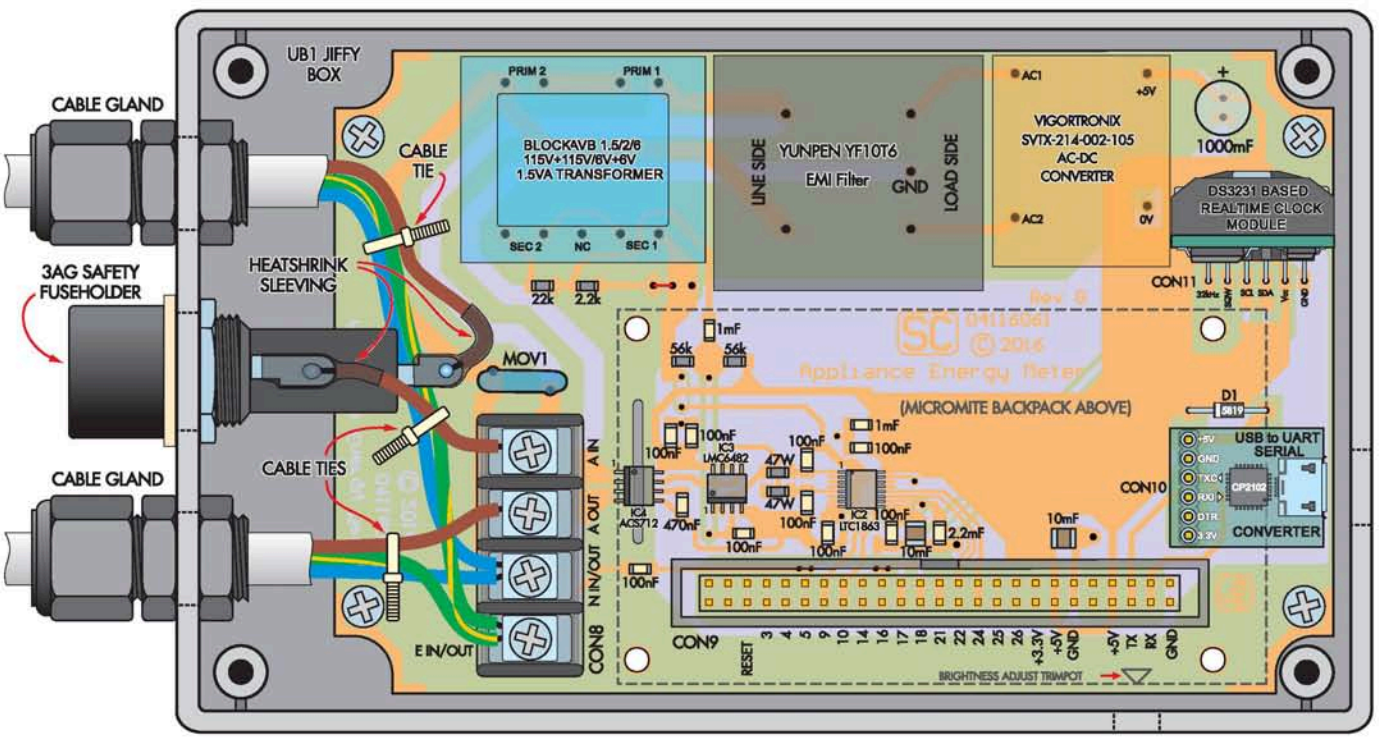


Fig.3: this diagram shows not only the component layout on the PCB but also its connections and placement within the UB1 Jiffy Box. Take care when identifying (and then soldering) the surface-mount components onto the board – all SMDs should be in position before mounting the transformer, EMI filter, AC-DC converter, serial converter, CON8, 9, 10 and 12.

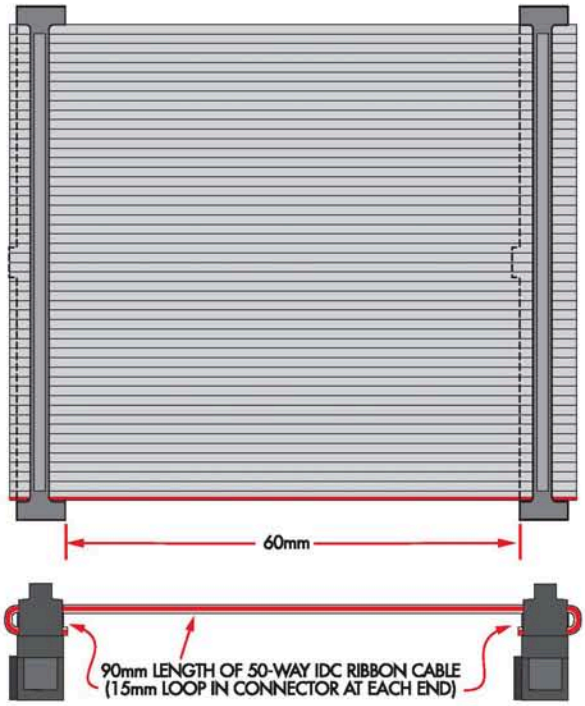


Fig.4: here's how the IDC cable is made up with its two connectors – note the loop and direction of the cable.

the larger pins and wider spacing.

The next step is to fit the six SMD resistors and 15 SMD capacitors using a similar technique. Basically, you just tack them in place at one end, then solder the other end before refreshing the initial joint. Make sure that solder flows onto both the PCB pad and the leads of each device.

The resistors will be marked with value codes on the top (eg, 223 or 2222 = 22k). Capacitors will be unmarked so you will need to take care not to get them mixed up after removing them from their packaging. None of these parts are polarised.

Through-hole components

Now fit through-hole diode D1 with the cathode stripe positioned as shown and then solder a standard 6-way pin header in place for CON10.

Now fit the box header in place for CON9 with the notch towards the top as shown in Fig.3 and on the PCB silkscreen. Follow with the 1000µF electrolytic capacitor, with its longer lead through the pad indicated with the plus sign. You can now fit the 4-way terminal barrier for CON8 along with the USB/serial adaptor board, which is soldered to the pin header already in place on the PCB, with the microUSB socket on the top. MOV1 can then be fitted and it can go in either way around.

That just leaves transformer T1, the EMI filter, the Yunpen AC/DC adaptor and real-time clock modules. Ensure that each one is pushed down fully onto the PCB before soldering its leads. Only the real-time clock module can be installed the wrong way around – it's mounted vertically but make sure that the main body of it sits next to the AC/DC converter; see Fig.3. If unsure, check the labelling on this module's pins and line them up with the corresponding labels on the PCB before soldering.

Note that you will want to fit the button cell to the real-time clock module before soldering it to the board and that, if you are using a non-rechargeable (primary) cell, you will need to first desolder the surface-mount, glass-encapsulated diode from the module so that the module won't try to charge it when power is applied.

Making the connecting cable

The LCD BackPack and main PCB are joined by a 50-wire IDC cable that's around 60mm in length. You will need to crimp the two 50-way IDC sockets onto either end of the cable as shown in Fig.4. You can either use a vise, with protective pieces of timber on either side of the assembly or an IDC crimping tool such as the Altronics T1540. We don't suggest you use a different tool such as pliers since this is likely to result in the plastic connector fracturing.

Once you've made the cable, taking care that the ribbon is properly aligned and the connectors are fully clamped down, the next step is to do some basic checks to make sure everything is working before putting it in the case.

Initial testing

First, plug a microUSB cable into the socket on the main board and plug the other end into your computer. The red LED on the real-time clock module should light up.

If you are using Windows 10, Mac OSX or Linux, the serial port should be automatically identified. If using an older version of Windows, download and install the SILICON CHIP USB serial driver. Verify that a new serial port is available, eg, by running a terminal emulator such as TeraTerm Pro and checking the list. You can open it and type some characters into the terminal but all that will happen is the LED on the USB/serial adaptor should flash.

Once you've verified that the USB serial port is working, unplug the cable and connect the BackPack module to the main PCB, using the ribbon cable you prepared earlier. This can only go into the socket on the main PCB

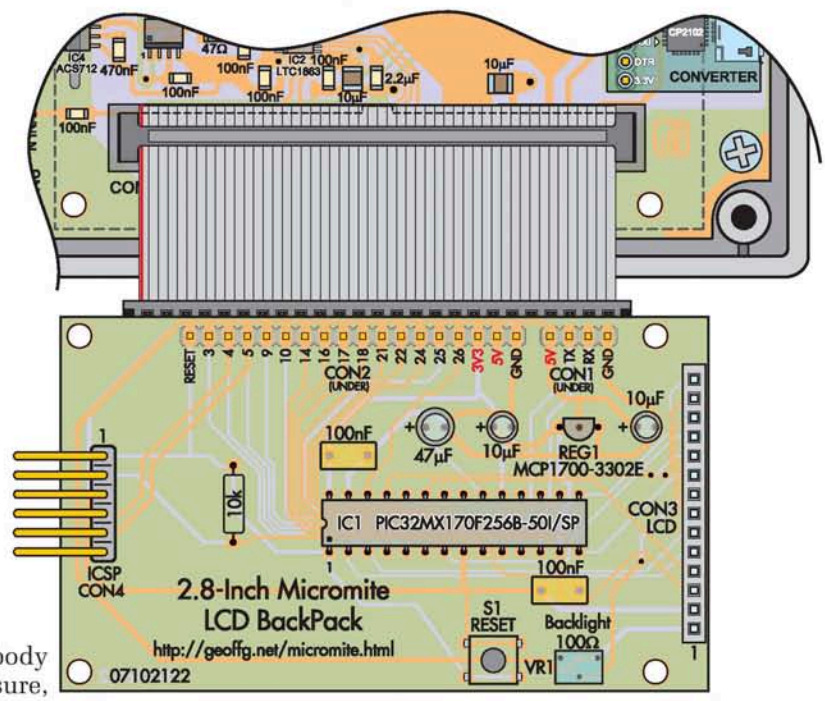


Fig.5: how to connect the LCD BackPack to the main PCB for testing (the TFT touch screen is not shown for clarity).

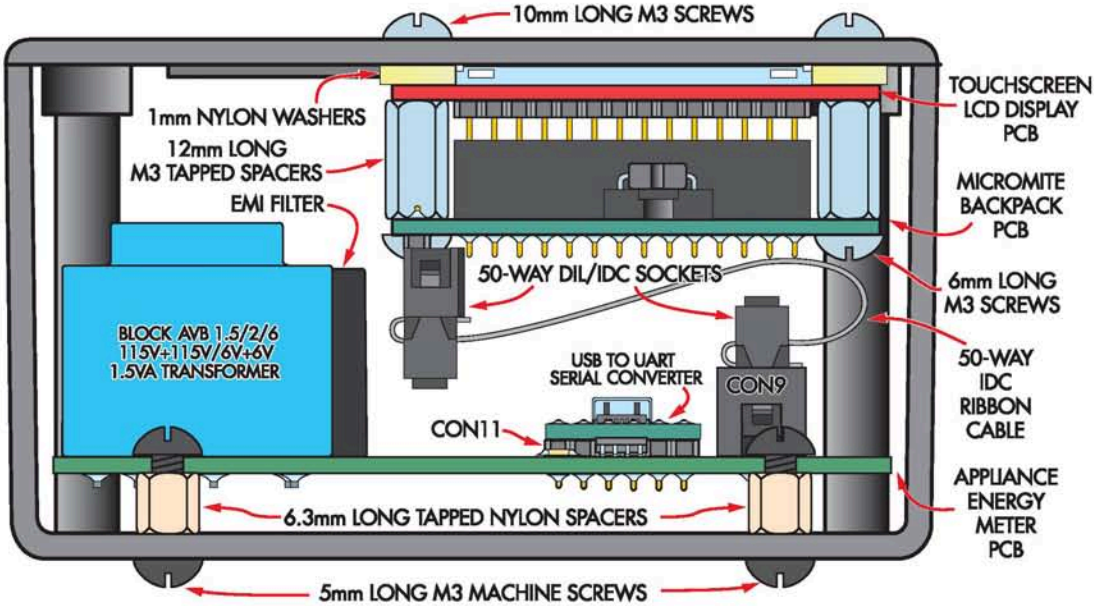


Fig 6: it's a snug fit but all the components mount inside the UB1 Jiffy box, as shown here. Compare this and the photo on page 88 when assembling. Case drilling details are shown on page 95. Note: this diagram is shown oversize, for clarity.

one way but you will need to be careful to plug it into the BackPack with the correct orientation; refer to Fig.5. For the moment, rest the BackPack module on your bench top as shown. Note that the TFT is not shown fitted on top of the module, for clarity.

The trick here is to make sure that the GND pin of the BackPack goes into either of the right-most holes on the IDC socket. You can then check for continuity between GND points on the two boards to confirm that it is located correctly; for example, place one probe on the via just to the right of the 10uF capacitor immediately to the left of the USB/Serial converter on the main PCB and the other probe on pin 3 of the BackPack ICSP header (CON4).

Now plug the USB cable back in. If you've used a microcontroller that was pre-programmed with the Appliance Energy Meter firmware, almost immediately you should

Uploading the code to the Micromite chip

Most constructors will simply purchase a pre-programmed PIC or download and install the HEX file which includes MMBasic along with all our code, so that the micro is ready to go. But some readers may wish to modify the code and because we had to resort to some tricks to make it fit, here is the multi-step procedure used to load it.

First, program your PIC32 with the MMBasic 5.1 firmware and establish a serial console connection using the USB converter. You will need to set up the display and touch panel as detailed in the February 2016 article on the LCD BackPack. Note that the BackPack (and, if attached, the main board) are powered from the PC during the programming process.

The first step is to load the **SCAppEnergyMeter_Library.BAS** into the Micromite. First, download the code from the SILICON CHIP website, then grab a copy of Jim Hiley's Windows/Linux "MMEdit" program. It is freeware and available from www.c-com.com.au/MMedit.htm For Windows, download the setup file called MMEdit.exe and run it. It works on any Windows version since XP.

Run MMEdit and open the BASIC file mentioned above. Next, ensure the "Auto crunch on load" option in the Advanced menu is selected and set up the COM port to communicate with the Micromite by selecting the "New..." option under the Connect menu. You can then click the "Load and run current code" button, right-most in the toolbar under the menu (with the icon that looks like a blue stick figure). You should get a progress dialog and the upload will take around 30 seconds.

If it fails, close this window and re-check the COM port settings (make sure you don't have this open in another program).

Once the upload is complete, the MMChat console window should automatically appear. You can then execute the "LIBRARY SAVE" command (note: if you have previously done this, you will need to run "LIBRARY DELETE" first). After a brief delay, it should display the MMBasic prompt, "> ". You can verify that the code was saved by issuing a "MEMORY" command, which should yield a response like:

```
> memory
Flash:
 0K (0%) Program (0 lines)
 18K (31%) Library
 42K (69%) Free
```

Now open the **SCAppEnergyMeter_Main.BAS** file (which is supplied in the same ZIP as the BASIC file loaded earlier) and, again ensuring that the "Auto crunch on load "option is enabled, upload that to the PIC32. The MMChat window should appear once this is complete. You can then type in "OPTION AUTORUN ON", press enter, then execute the "RUN" command to start the program.

Note that this will fail, with a real-time clock error, if the BackPack is not yet plugged into the main board. Regardless, you can now unplug the USB lead and proceed with the remainder of construction/set-up.

see the main screen come up. The readings may not all initially be zero but they should drop to zero after a few seconds (you may get a current reading of around 60mA since the unit has not been calibrated yet). Touch one of the elements on the screen and verify that it takes you to a different screen.

If your microcontroller has been programmed for the Micromite Mk2 but you do not yet have the Appliance Energy Meter software installed, connect to the USB serial port with a terminal emulator set to 38400 baud and press the reset button on the LCD BackPack. You should see the Micromite prompt in your terminal emulator. You can then use the multi-step procedure detailed in the side-panel to load the firmware.

Once the software is running, it's a good idea to check that the real-time clock and ADC are working. Checking the real-time clock is quite easy; press on the time and date in the lower-right corner of the screen to set it, then once it has been set, pull out the USB plug and then plug it back in. Once the unit restarts, it should retain the date and time. That indicates the real-time clock and its backup battery are OK.

Testing the ADC is a bit more tricky. If you're getting a zero voltage reading, that's a good sign. However to be sure, the easiest way is to pass some current between the "A IN" and "A OUT" terminals on the PCB (eg, from a DC supply with a current-limiting resistor) and check that it registers on the display.

You can reverse the polarity and you should get a similar reading but note that it won't be exactly the same, as the unit has not been zeroed yet.

If you have a fully programmed BackPack but get a blank display, there are a few things that might be wrong. Firstly, check that the ribbon cable has been made properly and correctly plugged in at both ends. Check also that the red LEDs on the real-time clock module and USB/Serial modules are lit. Run a terminal emulator, connect to the USB serial port at 38,400 baud and press the reset button on the LCD BackPack. See if you get any error messages which may give you a clue.

For example, if the micro can't communicate with the real-time clock it will issue an error message and halt. You would then need to check that the clock module is soldered properly and orientated correctly.

If you're getting nothing on the display and no error messages over the serial console, there is likely something wrong with the BackPack module itself, possibly in the TFT connections or a bad component or solder joint, so check it carefully.

Case preparation

The next step is to prepare the case. First, drill the holes for mounting the main PCB in the base. You can either use the diagrams on P95, use the PCB as a template, positioned as far to the right as possible (see Fig.3) or download the drilling diagram from the SILICON CHIP website and use that as a template. The four mounting holes are drilled to 3mm.

Now fit 6.3mm tapped Nylon spacers to the inside of the box using 5mm M3 machine screws and tighten them up. We recommend the use of Nylon machine screws for the attachment of the spacer at lower left (both top and bottom), which will be closest to the mains wiring when the unit is complete.

If you can't get a 5mm Nylon machine screw, consider using a longer Nylon screw fed through an untapped spacer and secure with a Nylon nut, although this will be a lot more "fiddly" to attach.

Now is a good time to attach some rubber feet to the bottom of the box. Adhesive types are the easiest, however you could use slightly longer screws to attach the Nylon spacers and also hold screw-on feet in place (but make sure they don't project any more than 3mm into the spacers), or simply drill four extra holes and attach the feet that way.

Before fitting the PCB into the box, drill the three round holes at the left end for the mains cable and fuseholder and make the rectangular cut-out on the right side for access to the USB socket. Details are in the drilling and cutting templates mentioned above and available for download from our website, as well as being shown on page 95.

The best approach for the round holes is to start with a small drill (eg, 3mm) and use either a tapered reamer, stepped drill bit or series of larger drill bits (going up by 1-2mm at a time) so that the holes are nice and round. Once they're large enough, test fit the components, then de-burr the holes using a larger drill bit or countersink tool.

The rectangular cut-out can be made by drilling a series of holes inside the perimeter with a small bit, cutting the remaining plastic to remove the inner piece, then filing the edges smooth and flat with a flat needle file.

The drilling diagrams also show a hole in the front of the box, so that you can access the brightness adjustment trimpot on the LCD BackPack board with a small screwdriver. This is optional however it may be a good idea as it will allow you to reduce the display brightness for lower power consumption during long-term power logging and then increase it again when you want to read the results.

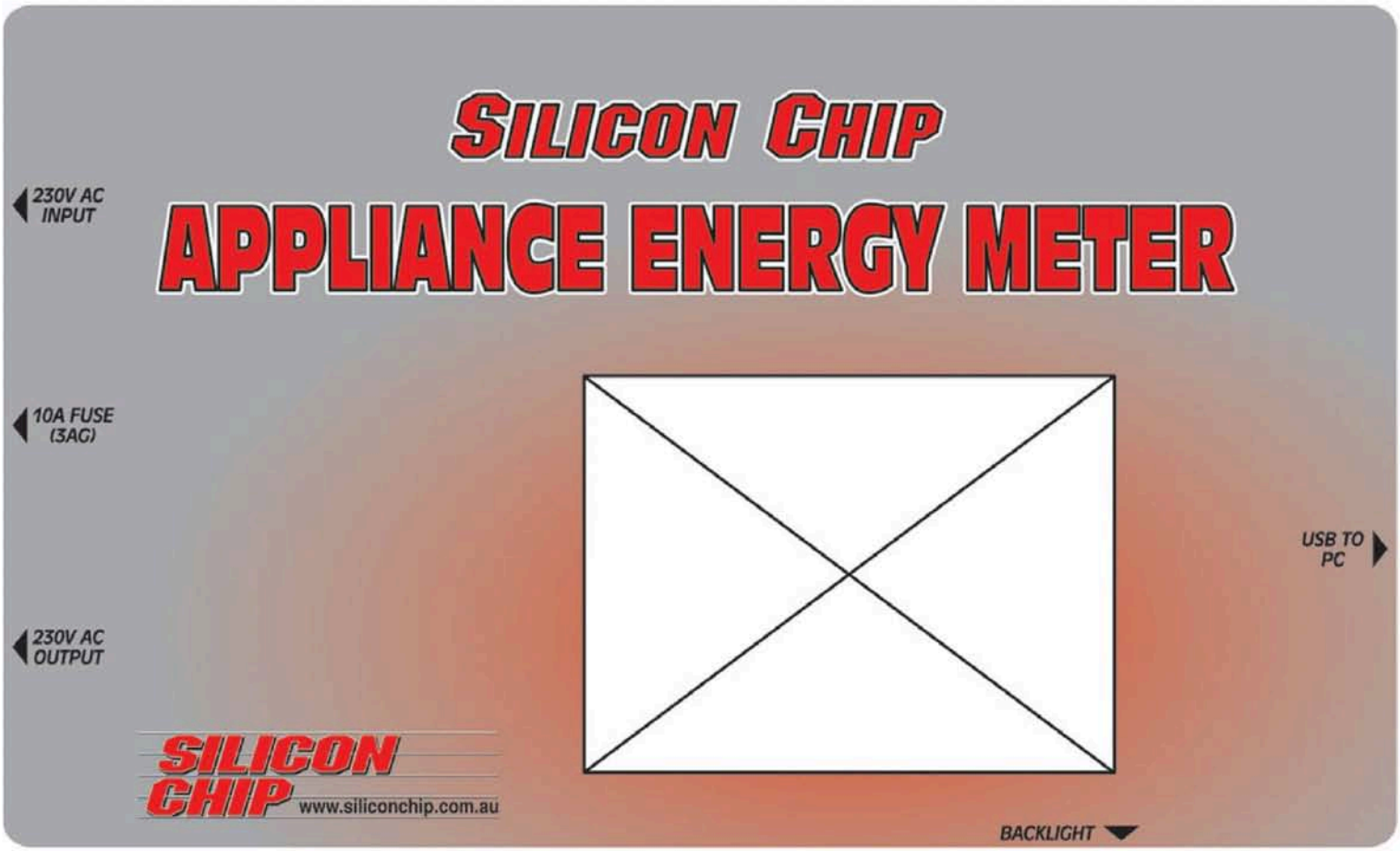
For the lid, a large, rectangular cut-out plus four 3mm mounting holes are required to suit the LCD BackPack. It's quite hard to do a neat job cutting the hole for the display. By far the easiest approach is to simply buy a replacement laser-cut black acrylic panel from the SILICON CHIP online shop.

You may need to use longer self-tapping screws than those supplied with the case, as this panel is slightly thicker than the existing lid and lacks the recessed holes for the screw heads – it depends on how long the supplied screws are as this can vary, based on case manufacturer. But it does give a neat appearance and you can still attach a lid label should you wish to. Alternatively, download the cutting diagram and make the holes in the original lid, using a similar technique as described above.

Putting it all together

The next step is to fit the 3AG safety fuseholder into the centre hole in the left-hand end of the box, using the pliant washer and mounting nut supplied. Tighten up the nut firmly, with the body of the fuseholder positioned so that the side connection lug is in a position that allows easy access for soldering.

You can then mount the two cable glands. Tighten up the internal nuts to secure the bodies of the glands but leave the outer nut loose. Now cut the 3m 230V/10A extension cable in half. If you don't have a 60mm length of 10A brown mains wire handy, cut a 60mm long piece off the input cable (ie, with the 3-pin plug on the end) and strip its insulation off.



Front panel artwork for the Appliance Energy Meter, reproduced here at exactly 100%, to fit the UB1 Jiffy box specified in the parts list last month. Note that holes are not shown – drilling details are in the diagram on page 95.

Strip 6mm of insulation from one end of the 60mm brown wire and 10-12mm from the other. Solder the shorter bared end to the fuseholder's side connection lug, making sure to produce a reliable joint, then slip a 15mm length of 5-6mm heatshrink sleeving over the joint and shrink it down (eg, using a hot air gun), making sure it covers as much of the exposed metal as possible.

Now remove about 85mm of the outer sheath from the cut end of the input cable, to free the three insulated wires inside. Cut the brown (Active) wire shorter than the others, to about 40mm, and remove about 6mm of the insulation from the end. At the same time, 10-12mm of insulation can be removed from the ends of the blue (Neutral) and green/yellow (Earth) wires.

Then push all three wires into the box through the input cable gland, at upper left. You may need to remove the outer nut entirely but don't lose the rubber sleeve in the process. Slip another 15mm length of 5-6mm heatshrink tubing over the brown wire and push it all the way down, then solder this wire to the lug at the rear of the fuseholder, making sure you make a secure and reliable joint. Once this has cooled down, slip the heatshrink tubing over the joint and shrink it down.

The next step is to lower the PCB into the case and secure it to the previously installed mounting posts at each corner, using M3 x 5mm machine screws.

As mentioned earlier, use a Nylon screw in the lower-left corner. You can then secure the bare end of the wire from the fuseholder under the clamping plate of the top-most terminal of CON8, labelled "A IN". Route the wire to the side of the screw furthest from the adjacent terminal and make sure there are no loose strands of copper and that it's screwed down firmly.

You can now remove about 40mm of the outer sheath from the end of the remaining half of the extension cable, ie, with the 3-pin socket at its other end. Having done that, strip 10-12mm of insulation from each of the three insulated wires. Push this through the other cable gland and feed the two blue Neutral wires (ie, one from this cable and one from the other) into the "N IN/OUT" terminal of CON8 and clamp them down firmly.

You can now complete the wiring by doing the same with the green/yellow striped Earth wires and finally, the brown Active output wire; see Fig.3 and the photo for details.

Having completed the wiring, gently pull the two mains leads out of the cable glands until there is only a little slack left on the internal wires, then screw the gland nuts down firmly and add cable ties where shown in Fig.3.

Note that we're going to glue the gland nuts in place later, so that they won't come undone, but we want to do some more testing before making it permanent.

Connecting the BackPack

The BackPack can now be secured to the inside of the lid; see Fig.6 for details. Remove the screws holding the LCD onto the spacers and feed four 10mm M3 machine screws through from the top side of the lid.

You may want to countersink these holes or use black screws to match the lid.

Pop 1mm-thick Nylon spacers (3mm inner diameter, 6mm outer diameter) over the ends of the screws, then feed them into the spacers through the LCD panel, with

Fitting the software into the Micromite

During the development of this software, we struggled to fit the required functions into the available flash memory and RAM of the 28-pin Micromite Mk2. While surface-mount PIC32s have up to 512KB flash and 128KB RAM, the DIP-package versions are limited to 256KB flash and 64KB RAM, with roughly 50KB of each available to MMBasic.

RAM limitations

Our goal was to be able to log up to one week of data to RAM, with a maximum logging interval of one minute. We managed to compact the voltage, current and power readings into 32 bits (four bytes). So one week of data requires 60 (minutes) x 24 (hours) x 7 (days) x 4 (bytes) = 40,320 bytes of RAM.

After that and taking into account MMBasic's overhead, that left us with about 10KB of RAM. That sounds like a lot, given that our program requires less than 1KB of general variables. Unfortunately though, during software development, we frequently ran out of memory and had to make significant changes to the software to work around this limitation. We also had to frequently rationalise the code so that it (and the fonts) would fit into the 50KB of available flash program space.

To make matters worse, changes to reduce RAM usage would often increase flash usage and vice versa. So we had to perform iterative optimisation, reducing the memory footprint, then shrinking the flash space used, then reducing the memory footprint again and so on until we were able to get all the required functions into the device.

Our challenges included:

1) *each MMBasic variable has several hundred bytes of overhead; we're guessing a fixed, relatively large amount of RAM is allocated to store the name of each variable. Just allocating a few integers (nominally 8 bytes each) can easily use up more than 1KB of RAM.*

Solutions: minimise the number of variables used; use arrays where possible (as the name only needs to be stored once); specify a maximum length for all string variables; use local variables wherever possible so that the RAM is freed once we have finished with them; combine multiple flags into a single integer variable; pack configuration data into strings; refactor code to use fewer local variables; do not use constants (making the code messier, unfortunately).

2) *each level of MMBasic function or subroutine recursion uses around 1KB RAM. Therefore, just a few levels of call depth can exhaust available RAM.*

Solutions: "flatten" functions, ie, when a subroutine or function is only called from one place, integrate it into the "parent" - this makes the code harder to work with and read but it uses less RAM; use CFUNCTIONs where this can't be avoided, especially for code that must be called in deeply recursed subroutines, as they have much lower stack and variable overhead.

3) *complex string pasting expressions allocate many temporary strings, which can easily add up to several kilobytes.*

Solutions: split up such complex expressions, placing temporary strings into local variables with limited size to reduce RAM usage; perform complex string processing in CFUNCTIONS which don't have this limitation.

4) *fonts and CFUNCTIONs use up a lot of flash.*

Solutions: use a minimal number of fonts (two, plus the built-in font); place all fonts in the LIBRARY section where they are compressed; also place as many CFUNCTIONs as possible in the LIBRARY section (one of the two will fit).

5) *the program is too large to fit in flash.*

Solutions: place as many extra function as possible in the LIBRARY section, where they are compressed; re-factor code to reduce repetition and take advantage of subroutines, recursion and loops (possibly increasing RAM usage); use the MMEdit "crunch" feature which strips out unnecessary spaces, comments, etc from the program when uploading to the Micromite; use shorter variable and subroutine names; refactor code to use more compact expressions which perform the same operation; remove any unused or redundant code; hard-code display dimensions.

```
LOCAL INTEGER count, t
LOCAL v, a, pf
LOCAL temp$(8) LENGTH 18
FOR count = 1 TO num_datum-1
  t = (count-1)*log_interval
  v = get_datum(count, "v")
  a = get_datum(count, "a")
  pf = get_datum(count, "pf")
  temp$(1) = STR$(count)
  temp$(2) = STR$(t)
  temp$(3) = duration_str$(t)
  temp$(4) = STR$(v,0,1)
  temp$(5) = STR$(a,0,3)
  temp$(6) = STR$(v*a,0,1)
  temp$(7) = STR$(v*a*pf,0,1)
  temp$(8) = STR$(pf,1,2)
  print temp$(1)+","+temp$(2)+","+temp$(3)+","+temp$(4)+"
,"+temp$(5)+","+temp$(6)+","+temp$(7)+","+temp$(8)
NEXT count
```

This code snippet from the logging output portion of the code shows how using string arrays with fixed length can be used to paste multiple values together with lower memory overhead than simply using a single, long expression.

```
long long int main(const char* date, const char* time, const
char* tariff_times, const char* holidays) {
  unsigned int i, day, mon, year, hour, min, dow, offset;
  day = bcd2_to_int(date+1);
  mon = bcd2_to_int(date+1+3);
  year = bcd2_to_int(date+1+8);
  if( dow > 0 && dow < 6 ) {
    for( i = 0; i < 22; ++i ) {
      int holday, holmon, holyear;
      holday = bcd2_to_int(holidays+1 + i*6);
      holmon = bcd2_to_int(holidays+1 + i*6 + 2);
      holyear = bcd2_to_int(holidays+1 + i*6 + 4);
      if( holday == day && holmon == mon && holyear == year)
      {// it's a public holiday, woohoo
        dow = 0;
        break;
      }
    }
  }
  ...
```

This partial CFUNCTION shows how the lower function call overhead and ability to pass pointers into strings eliminates the memory associated with temporary sub-strings.

the brightness adjustment pot towards the edge of the lid.

If you're using the laser-cut lid, you should find that the display fits snugly through the provided cut-out although you may need to keep the screws loose initially in order to line it up. If using a self-cut lid and it doesn't fit first time, you will have to remove the display and do some filing.

Once it's secured in place, you can attach the ribbon cable as shown in Figs.5 & 6. Again, be careful to ensure that the pins on the BackPack are properly aligned with its IDC header and check for GND continuity.

Now would be a good time to attach a label to the lid. Artwork can be downloaded from the SILICON CHIP website. You have various options for producing the label:

1) print it onto plain or photo paper, then laminate it and either glue it to the lid (eg, using silicone sealant) or attach it using thin double-sided tape.

2) mirror it and print it onto overhead transparency film, then attach it to the lid using a thin smear of silicone sealant.

3) use Datapol/Dataflex printable labels (to suit laser printers or inkjet printers respectively).

Regardless of which method you use, cut out the holes for the LCD and mounting screws using a sharp hobby knife before affixing the label to the lid. One advantage of attaching a lid label is that it will cover the non-viewable area of the TFT, for a neater appearance. But since pretty much all interaction is done via the touchscreen, a label is not mandatory.

Before attaching the lid to the box, re-check the mains wiring, especially the wires going into CON8 and make sure that there are no stray strands of copper wire that could short to anything else and that all the connections are secure. Then fold the ribbon cable under the BackPack and attach the lid to the box using four black self-tapping screws.

More testing

Now for the real test. Make sure nothing is plugged into the socket end of the mains cable and the lid is securely attached, with no loose wires. Place a fuse in the fuse holder; you can use a 1A fast-blow fuse for now and replace it with a 10A slow-blow fuse as specified later, so that it will blow faster in the unlikely event of a fault.

Place the unit in a secure location where it won't fall off under the weight of the mains cables or be knocked off, then plug it into mains and switch it on. The LCD backlight should be illuminated immediately and display should come up soon afterwards (you already tested this earlier, so all we are really testing here is the mains power supply).

Verify that the voltage reading is reasonable, ie, around 230VAC but keep in mind that you haven't calibrated it yet. The current, VA and power readings are not going to be zero for the same reason but they should drop to a low level after about ten seconds (less than 100mA, less than 10VA and under 5W). If not, that suggests something is wrong so switch off, unplug the unit and check for faults, especially bad solder joints.

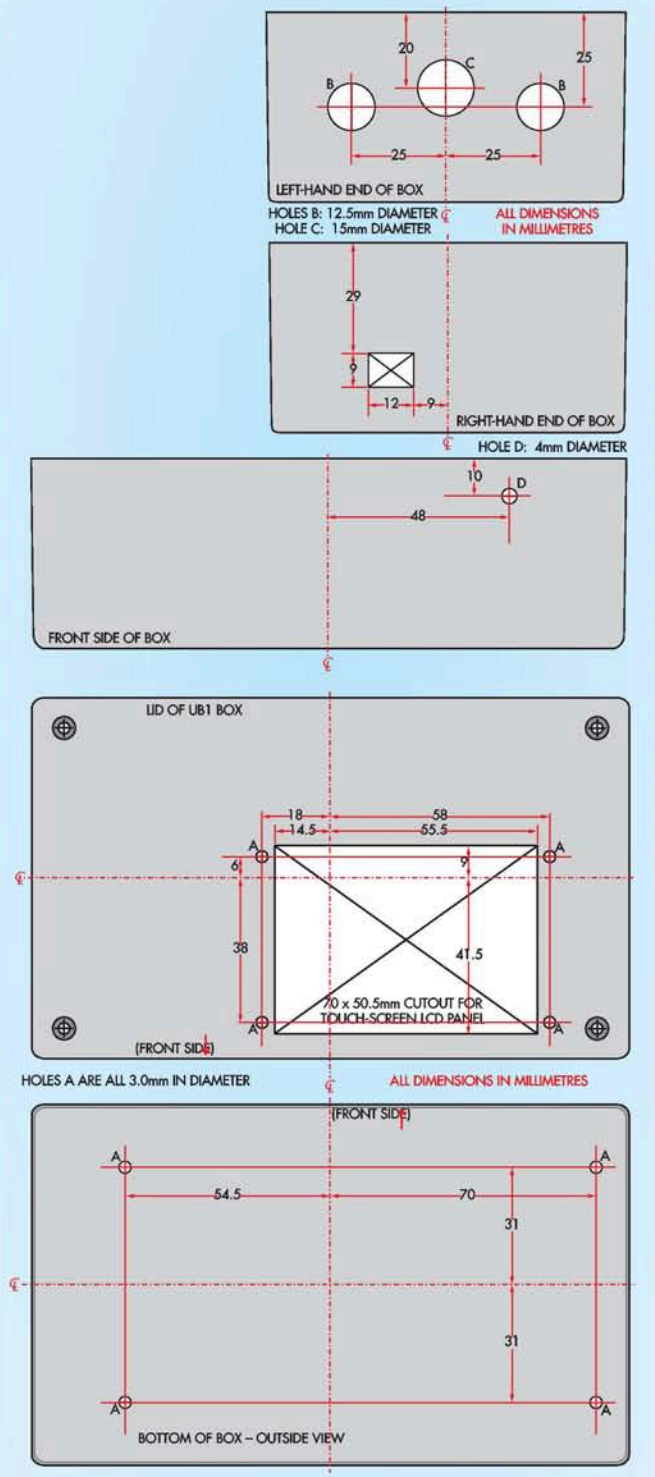
Next month

To conclude the Touchscreen Appliance Energy Meter, next month we'll go over the calibration procedure and give more information on how to use the unit. We'll also give some details on the CFUNCTIONs we used to augment the BASIC code and provide the required functions for the meter to perform well. SC

Box drilling and cutting diagrams

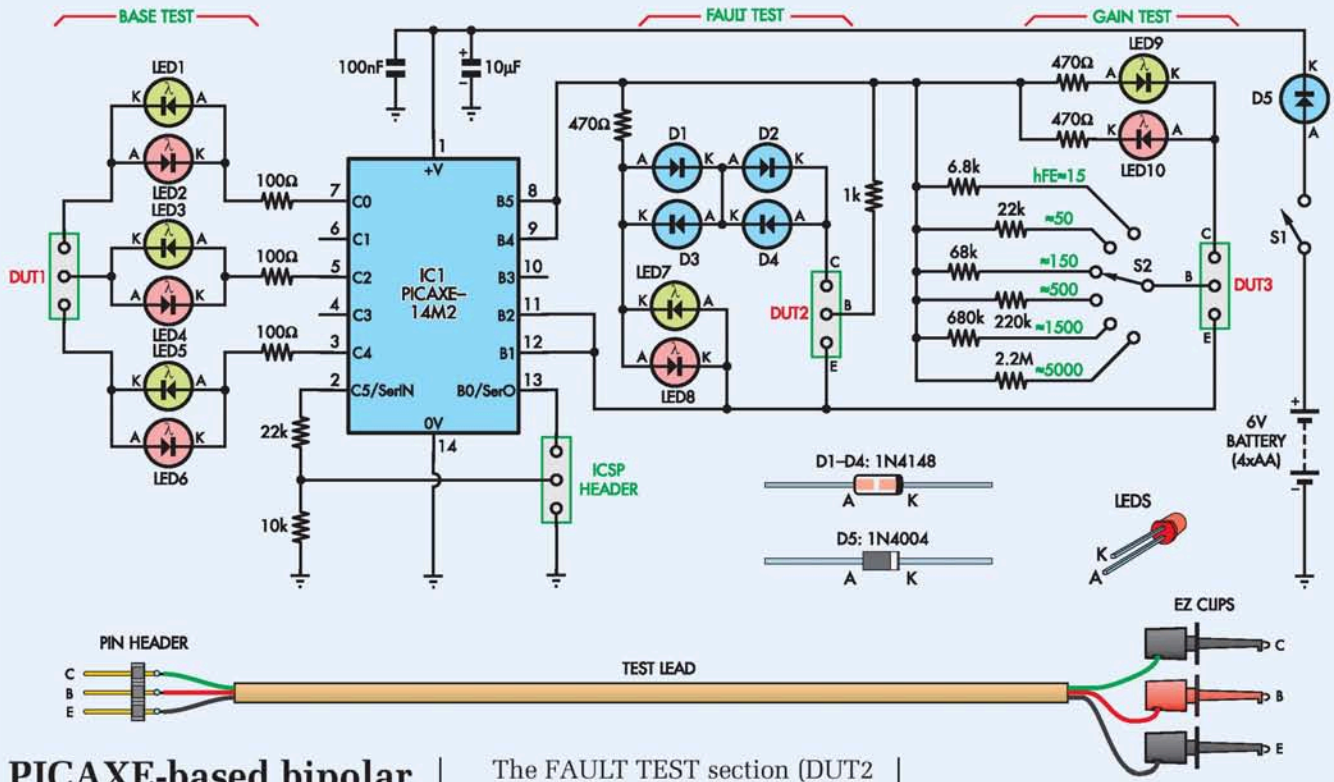
Shown below are the holes and cutouts required in the UB1 Jiffy box. These diagrams are shown exactly half size, so if you enlarge them with a photocopier to 200% they can be used as drilling and cutting templates.

Alternatively, you can download them from www.siliconchip.com.au (see the downloads section) and print them at 100% to use them as templates. Colour front panel artwork can also be downloaded from this source.



CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



PICAXE-based bipolar transistor tester

This project combines three simple transistor test circuits in one handy device. It shows transistor polarity, identifies the pins, finds junction faults and tests gain. The device under test (DUT) is clipped to the test lead and moved to each test socket (DUT1-DUT3) in turn. The PICAXE14M2 alternately drives the transistor pins to allow both NPN and PNP types to be tested.

The BASE TEST section (DUT1 socket) identifies the base pin and shows if the transistor is an NPN or PNP type. The circuit includes a red and green LED for each pin of the transistor and both LEDs will turn on for the emitter and collector pins, while a single LED will turn on for the base pin. The base lights the green LED for an NPN transistor or the red LED for a PNP transistor. If the base is not indicated for the centre pin, the clips can then be re-arranged to give the correct connections for the remaining tests.

The FAULT TEST section (DUT2 socket) finds faulty junctions. A good NPN transistor lights green LED7 and a good PNP transistor lights red LED8. This tester is able to identify open or shorted collector-emitter or base-emitter junctions. Both LEDs turn on with an open junction and both LEDs turn off with a shorted junction. Note that both LEDs also turn on when no transistor is connected, as this is equivalent to a transistor with an open junction.

The GAIN TEST section (DUT3 socket) identifies the emitter and collector pins and gives an idea of the gain of the transistor. The gain is tested by rotating S2 to the highest position that will fully illuminate green LED9 (NPN) or red LED10 (PNP). The higher the resistance selected, the higher the transistor gain; approximate gain values are indicated on the circuit diagram. Reverse the collector and emitter pins if the transistor exhibits very low gain. If this fails, the device may not be a transistor or could be faulty.

A simple BASIC program controls all three testers. Pins 3, 5 & 7 are driven in a 6-step sequence. All three start low and each is taken high in turn, then after all three are high, each is taken low in turn. For the fault tester and gain tester, parallel pairs of pins 8/9 and 11/12 are driven in anti-phase.

This circuit runs from a 6V battery pack (four AA cells or similar) and is controlled by power switch S1. D5 drops the voltage to just over 5V and also provides reverse battery protection.

The prototype used 3mm clear-lens LEDs as these provide a more concentrated beam. Headers for the test sockets were cut from Arduino shield strips (Jaycar HM-3207) These headers have extended pins, allowing the test sockets to be level with the LEDs.

The circuit also includes an ICSP header to download software into microcontroller IC1, with pin 2 as the serial input and pin 13 as the serial output signals. A PICAXE serial or

dsPIC/PIC programmer improvements

In 2008, I built the dsPIC/PIC Programmer described in the May 2008 issue of SILICON CHIP. I have used it successfully several times since. I left out diode D2 as I could not see why it was necessary and there is no such diode in my other programmers.

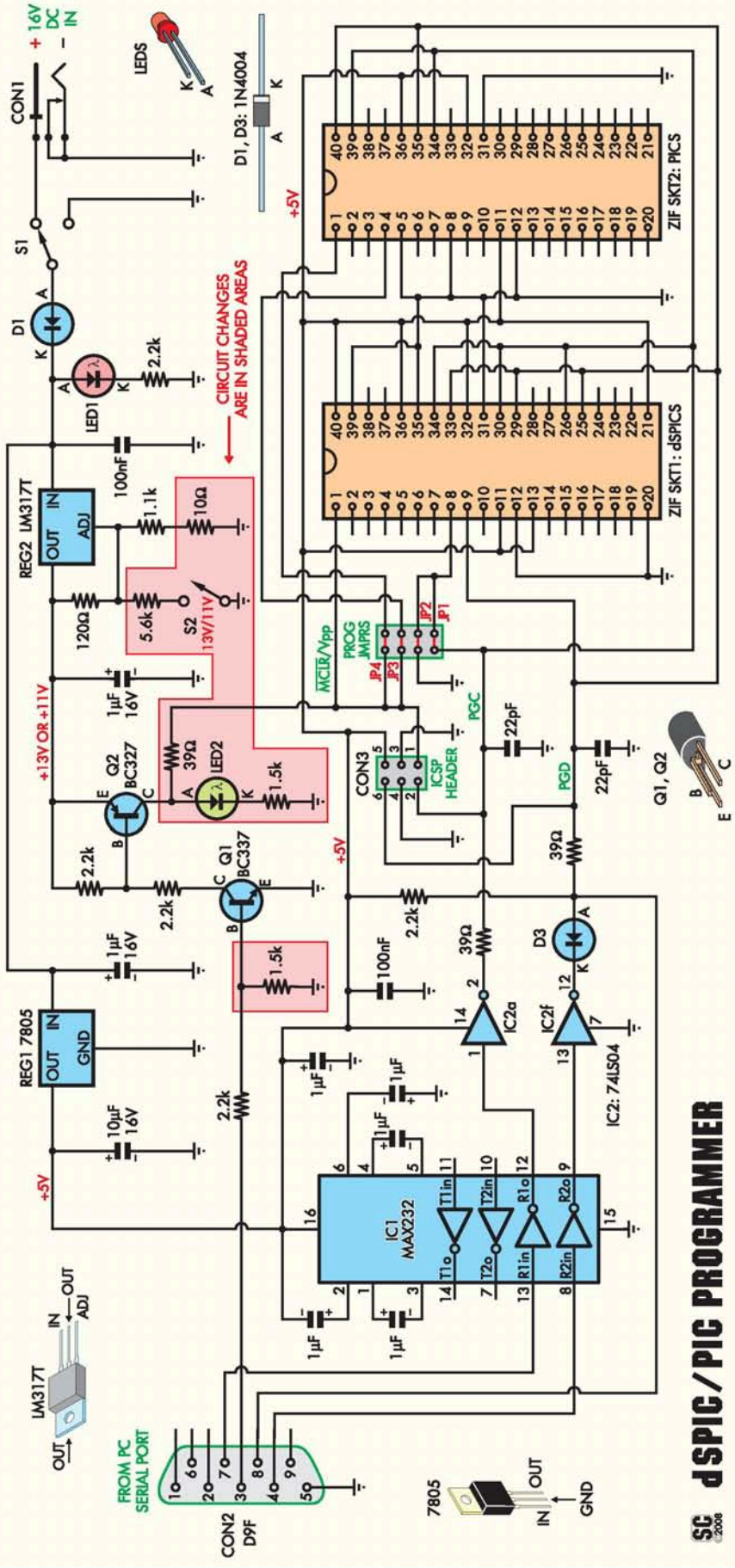
Recently, I decided to modify it to include LED2 to indicate when the Vpp programming voltage is applied and second, to provide a switch to change Vpp from 13V to 11V when programming a PIC such as the 16F684. The required programming voltage range for each type of chip is documented in the *Program Files (x86)\Microchip\MBLAB IDE\Device* folder (assuming you have MPLAB installed) – see, for example, PIC16F684.dev which states "vpp (range=10.000-12.000 dflt=11.000)".

When I switched the modified unit on, I noticed that LED2 came on for about two seconds. If I switched it off and then on after a short delay, LED2 did not light. But if I left it off for several minutes, LED2 would again flash at switch on.

I could not find any reason for this but I noticed that the voltage on the base of Q1 was about -11V due to the voltage coming from the PC via the RS-232 cable. The BC337 data sheet states that the maximum V_{EB} is 5V (ie, the base-emitter breakdown voltage is somewhat greater than -5V). So it appears that the transistor was damaged by the excess voltage. As a result, I replaced Q1 and added a 1.5kΩ resistor to reduce the applied base voltage.

The modifications are shown on the adjacent circuit. S2 is used to switch Vpp between 11V and 13V. Note the added 10Ω resistor in series with the 1.1kΩ resistor. These changes can all be made quite easily on the existing PCB.

Len Cox,
Forest Hill, Vic. ($50)



USB cable can be used to upload the **tran_tester14m2.bas** BASIC program, which is available from the SILICON CHIP website (free for subscribers).

Ian Robertson,
Engadine, NSW. ($60)

Ultra-low-power, long-range Arduino communications

This remote sensor module can operate for around one month on a single lithium button cell and transmits data to a remote station at least 500m away. Standard stub antennas are good for at least 500m line-of-sight while the home-made BiQuad antenna shown in the photo extends the range to at least 1500m, with a gain of around 12dB. Depending on how well the transmitter and receiver antennas are aligned, even greater ranges are possible.

The transmitter uses about 6-7mA while active, however it only needs to be active for a second or two periodically to transmit data. The average current is much lower, at around 0.3mA if transmitting data every 30-40 seconds. This equates to 6mAh/day, so a 150mAh cell will last around 25 days, while a Panasonic 220mAh CR2032 cell will last 30 days.

Both the transmitter and receiver units are based on an Atmel ATmega328PU microcontroller, as used in the Arduino Uno. They run at 4MHz and are connected to NRF24L01+-based 2.4GHz 2Mb/s low-power radio transceiver modules with a built-in power amplifier (for transmit) and a low-noise amplifier (for receive). The sensor unit also has a DHT22 sensor to monitor relative humidity and ambient temperature.

Because Arduino is relatively easy to program, constructors could quite easily alter the software to support more and different sensors but the DHT22 serves as a useful example of the capability of this design.

The radio modules can operate in one of 126 different channels, numbered 0-125 and spanning 2400MHz to 2525MHz, ie, each channel is separated by 1MHz. In Australia, channels 0-83 are able to be used however they are likely to include a lot of WiFi and Bluetooth traffic. Unfortunately, channels 100-125 overlap the 2.5GHz band which is licensed for Electronic News Gathering and use of the remaining channels is not permitted.

Perhaps the best strategy is to choose channel 0 or 83 as these are right at the edges of the WiFi spectrum and likely to have lower interference. The radio modules can also be configured for different data rates, CRC lengths and power levels; in this application, we're using a 256Kbps data rate, 16-bit CRC and maximum power (PA_MAX, 20dBm or around 100mW).

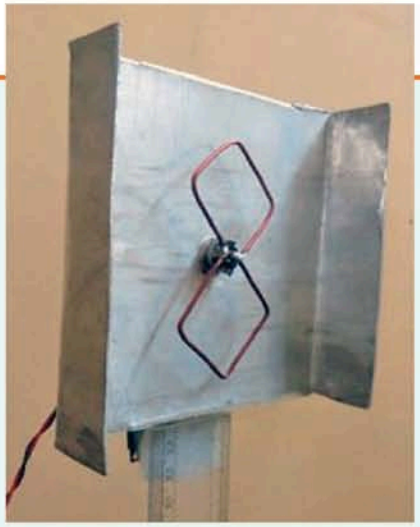
Between data bursts, the radio module is put into a low-power standby mode and the microcontroller is in "sleep" mode. Only its watchdog timer is left running and this wakes it up periodically, to gather data from the sensor and then transmit this via radio to the receiver station.

Software

The software to control the micro's sleep state is in the Arduino library file "lowpower.h". The NRF24L01 library includes a powerDown() function to put the radio module into its sleep mode. This library communicates with the radio module using an SPI interface. The micro also switches off power to the DHT22 sensor when it's not being used, as it's powered from one of the general purpose outputs.

Note that an Arduino Uno normally uses a 16MHz crystal so you need to flash the blank chip with the 8MHz Arduino bootloader (which uses the internal oscillator instead) before uploading the sketch. Note also that the circuit cannot be powered from 5V as the radio module's maximum supply voltage is 3.3V nominal.

There isn't much to the transmitter circuit. Besides the cell, power switch, micro, sensor and radio module, the only other components are three supply bypass capacitors, a pull-up resistor for the DHT22 open-collector output, plus a reset switch for the micro. The large supply bypass for the DHT22 is necessary because the I/O pin driving it can't supply a lot of current, so the capacitor is charged before the sensor is queried to avoid its supply voltage dropping too much during operation.



The receiver circuit is similarly spartan, with the DHT22 sensor removed and a 128x64 graphic LCD fitted instead, which is driven from the micro over an I^2C serial bus. Received data is also sent to the Arduino's serial console and may be logged on a PC for later analysis.

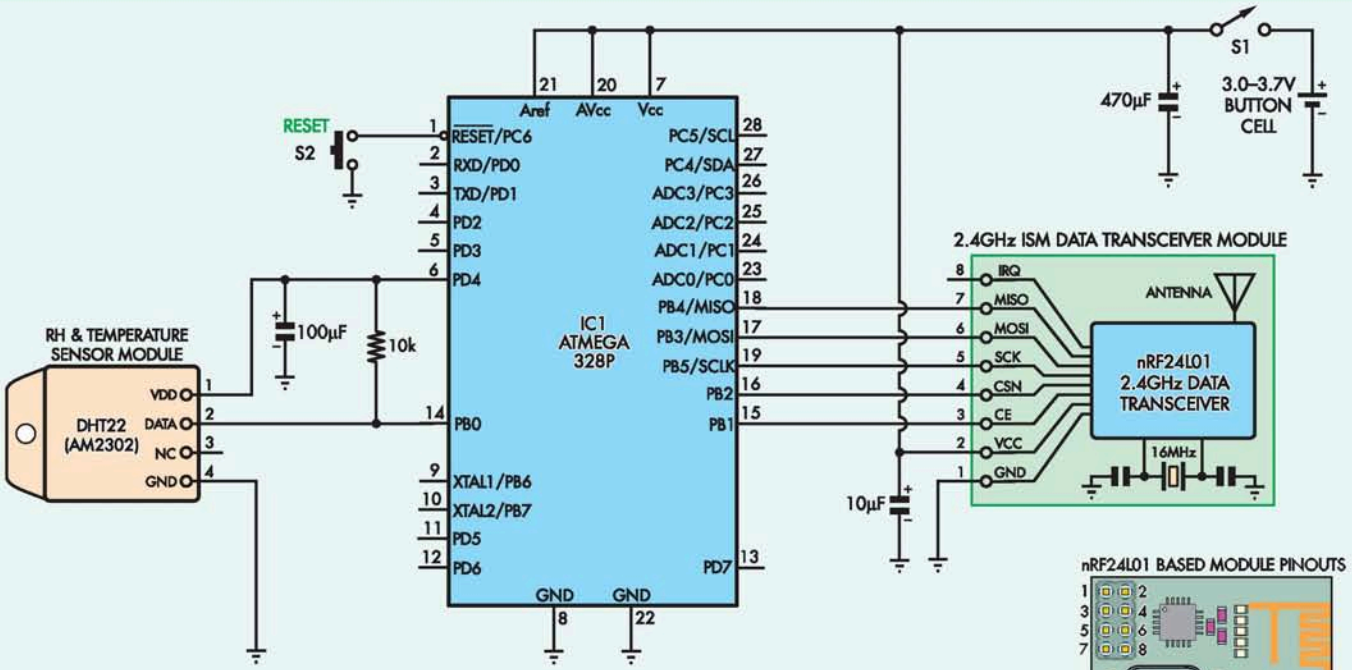
While the receiver is shown powered from a button cell, it draws a lot more current than the transmitter unit (partly due to the LCD), so a mains-derived 3.3V regulated DC supply may be more practical. Take care that the supply voltage doesn't exceed the specified 3.7V maximum.

Antenna

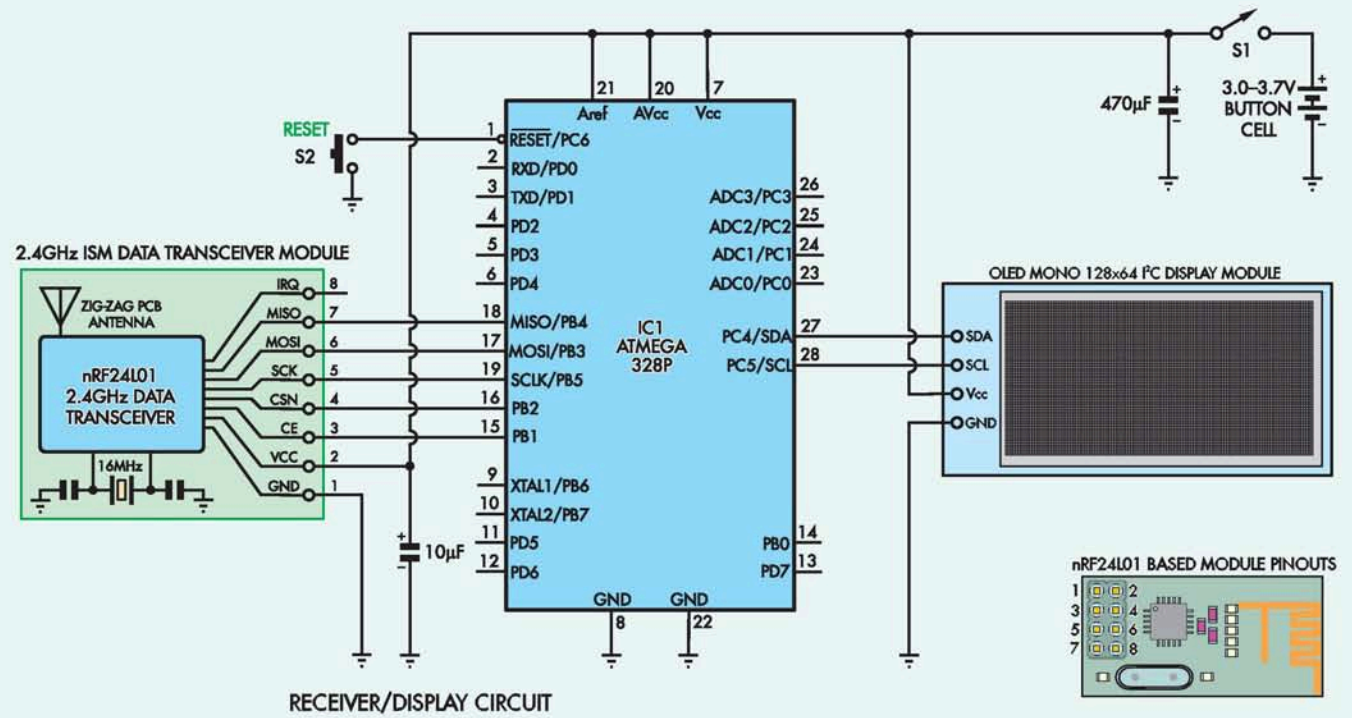
For shorter ranges, you can use standard 2.4GHz stub antennas which connect directly to the SMA socket on the radio modules and are available at low cost. However, much better range can be achieved using a home-made bi-quad antenna. The ideal dimensions for your chosen channel can be determined from

Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We need it and will pay good money to feature it in the Circuit Notebook pages. We can pay you by electronic funds transfer, cheque (what are they?) or direct to your PayPal account. Or you can use the funds to purchase anything from the SILICON CHIP on-line shop, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au



SENSOR/TRANSMITTER CIRCUIT



RECEIVER/DISPLAY CIRCUIT

this website: http://buildyourownantenna.blogspot.in/2014/07/double-biquad-antenna-calculator.html

Simply plug in the frequency you're using (eg, 2400MHz for channel 0) and press the "Calculate" button. Then form the antenna from stiff wire of the specified diameter, which will be around 1.38mm. This equates to a cross-sectional area of 6mm. It's soldered to the back of a panel-mount RF connector which is then attached to a sheet of aluminium, copper or copper laminate of the specified dimensions, around 125x125mm.

The photo shows one of the prototype antennas which achieved excellent performance at a distance of 1.5km. It wasn't possible to test at further ranges as no convenient location with line-of-site was available; it's possible that these antennas will provide much longer range than that.

This project is quite cheap to build, with the radio modules, sensors and LCD costing just a few dollars each on eBay or Ali Express. The software for both units (*LowPowerArduinoLongRangeComms.zip*) can be downloaded from the SILICON CHIP website.

Somnath Bera,
Vindhyanagar, India. ($70)

SILICON CHIP .com.au/shop ONLINESHOP

Looking for a specialised component to build that latest and greatest *Silicon Chip* project? Maybe it's the PCB you're after? Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the *Silicon Chip* ONLINESHOP.

As a service to readers, *Silicon Chip* has established the ONLINESHOP. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts such as PCBs & micros.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, regardless of how many boards or micros you order! (Australia only; overseas clients – email us for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

HERE'S HOW TO ORDER:

VISA MasterCard PayPal

All prices are in AUSTRALIAN DOLLARS ($AU)

✔ **Via the INTERNET** (24 hours, 7 days): Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links

✔ **Via EMAIL** (24 hours, 7 days): email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details

✔ **Via MAIL** (24 hours, 7 days): PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details

✔ **Via PHONE** (9am-5pm EADST, Mon-Fri): Call (02) 9939 3295 (INT 612 9939 3295) – have your order ready, including contact and credit card details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *Silicon Chip OnLineShop* stocks microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *2 chips – $15 pair* (Aug13). Driveway Monitor Receiver (July15) Hotel Safe Alarm (Jun16)
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14) Remote Mains Timer (Nov14), Driveway Monitor Transmitter (July15) Fingerprint Scanner (Nov15) MPPT Lighting Charge Controller (Feb16) 50/60Hz Turntable Driver (May16) **Cyclic Pump Timer (Sep16)**
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16LF1709-I/SO	Battery Cell Balancer (Mar16)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul 14)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jan15) – *also includes* ***FREE*** *47µF tantalum capacitor* Micromite LCD Backpack [either version] (Feb16) GPS Boat Computer (Apr16) Micromite Super Clock (Jul16)
PIC32MX170F256B-I/SP	Low Frequency Distortion Analyser (Apr15)
PIC32MX170F256D-501P/T	44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14), Digital Effects Unit (Oct14)
PIC32MX470F512L-120/PT	**Micromite Plus Explore 100** *(see below for full kit)*
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSiC DAC (Feb-May 13)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

NEW THIS MONTH:

MICROMITE PLUS EXPLORE 100 ****COMPLETE KIT (no LCD panel)**** *(Sept 16)* **$69.90**
(includes PCB, programmed micro and the hard-to-get bits including female headers, USB and microSD sockets, crystal, etc but does not include the LCD panel)

DS3231-BASED REAL TIME CLOCK MODULE
with two 10mm M2 spacers & four 6mm M2 Nylon screws *(Jul 16)* **$5.00**

100dB STEREO AUDIO LEVEL/VU METER
All SMD parts except programmed micro and LEDs (both available separately) *(Jun 16)* **$20.00**

RASPBERRY PI TEMPERATURE SENSOR EXPANSION
Two BSO150N03 dual N-channel Mosfets plus 4.7kΩ SMD resistor: *(May 16)* **$5.00**

MICROWAVE LEAKAGE DETECTOR - all SMD parts: *(Apr 16)* **$10.00**

BOAT COMPUTER - **(REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below])** *(Apr 16)*

BOAT COMPUTER - VK2828U7G5LF TTL GPS/GLONASS/GALILEO module with antenna & cable: **$25.00**

BOAT COMPUTER - VK16E TTL GPS module with antenna & cable: *(Apr 16)* **$20.00**

ULTRASONIC PARKING ASSISTANT (REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below]
Ultrasonic Range Sensor **PLUS** clear lid with cutout to suit UB5 Jiffy Box *(Mar 16)* **$7.50**

BATTERY CELL BALANCER
ALL SMD PARTS, including programmed micro *(Mar 16)* **$50.00**

MICROMITE LCD BACKPACK *** COMPLETE KIT ******* *(Feb 16)* ***$65.00**
includes PCB, micro and 2.8-inch touchscreen **AND NOW INCLUDES LID** *(specify clear or black lid)*

VALVE STEREO PREAMPLIFIER - *(Jan 16)* **$30.00**
100µH SMD inductor, 3x low-profile 400V capacitors & 0.33Ω resistor

MINI USB SWITCHMODE REGULATOR Mk II all SMD components *(Sept 15)* **$15.00**

ARDUINO-BASED ECG SHIELD - all SMD components *(Oct 15)* **$25.00**

ULTRA LD Mk 4 - plastic sewing machine bobbin for L2 – pack 2 *(Oct 15)* **$2.00**

VOLTAGE/CURRENT/RESISTANCE REFERENCE - all SMD components# *(Aug 15)* **$12.50**
includes precision resistor. Specify either 1.8V or 2.5V

MINI USB SWITCHMODE REGULATOR all SMD components *(July 15)* **$10.00**

BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC *(Jun 15)* **$2.50**

BALANCED INPUT ATTENUATOR - all SMD components inc.12 NE5532D ICs, 8 SMD diodes, SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole) *(May 15)* **$65.00**

APPLIANCE INSULATION TESTER - 600V logic-level Mosfet. 5 x HV resistors: *(Apr15)* **$10.00**

ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: *(Jan15)* **$40.00**
all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors:

CDI – Hard-to-get parts pack: Transformer components (excluding wire), *(Dec 14)* **$40.00**
all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor:

CURRAWONG AMPLIFIER Hard-to-get parts pack: *(Dec 14)* **$50.00**
LM1084IT-ADJ, KCS5603D, 3 x STX0560, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors

ONE-CHIP AMPLIFIER - All SMD parts *(Nov 14)* **$15.00**

DIGITAL EFFECTS UNIT WM8371 DAC IC & SMD Capacitors *[Same components also suit Stereo Echo & Reverb, Feb14 & Dual Channel Audio Delay Nov 14]* *(Oct14)* **$25.00**

AD8038ARZ Video Amplifier ICs For Active Differential Probe (Pack of 3 SMD) *(Sept 14)* **$12.50**

44-PIN MICROMITE Complete kit inc PCB, micro etc *(Aug14)* **$35.00**

MAINS FAN SPEED CONTROLLER - AOT11N60L 600V Mosfet *(May14)* **$5.00**

RGB LED STRIP DRIVER - all SMD parts and BSO150N03 Mosfets, does not include micro (see above) nor parts listed as "optional" *(May14)* **$20.00**

HYBRID BENCH SUPPLY- all SMD parts, 3 x BCM856DS & L2/L3 *(May 14)* **$45.00**

USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC *(Apr14)* **$7.50**

THESE ARE ONLY THE MOST RECENT MICROS AND SPECIALISED COMPONENTS. FOR THE FULL LIST, SEE www.siliconchip.com.au/shop

*All items subect to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. **# P&P prices are within Australia. O'seas? Please email for a quote**

09/16

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit*. If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

NOTE: Not all PCBs are shown here due to space limits but the SILICON CHIP ONLINESHOP has boards going back to 2001 and beyond. For a complete list of available PCBs, back issues, etc, go to *siliconchip.com.au/shop* Prices are PCBs only, NOT COMPLETE KITS!

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSiC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSiC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSiC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SiDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SiDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp [Sept11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01111131-3	$35.00/set
(for CLASSiC-D Amp board and CLASSiC-D DC/DC Converter board refer above [Nov 2012/May 2013])			
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender Mk2	JAN 2014	01112131	$15.00
Li'l Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$12.50
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/set
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	-	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7. 50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101141	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	1510815	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$6.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	03104161	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00
PRECISION 50/60HZ TURNTABLE DRIVER	MAY 2016	04104161	$15.00
RASPBERRY PI TEMP SENSOR EXPANSION	MAY 2016	24104161	$5.00
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Vintage Radio

By Ian Batty

Astor's M5/M6 5-transistor mantel sets

Despite using just five transistors, Astor's M5 & M6 radios are both good performers and make ideal kitchen "companions". The M5 is an all-PNP transistor design and the author's unit proved to be easy to repair and get going.

ASTOR RADIO Corporation began operation in 1926, based in South Melbourne. It quickly established a reputation for innovation because it offered radios in a variety of colours, compared to most other firms that offered standard timber cabinets only. The company later took over radio firms Eclipse and Essanay and went on to make a considerable contribution to the Australian radio industry.

Beginning, as many local makers did, with simple TRF sets, Astor soon progressed to producing superhet consoles, mantel sets and portables. The introduction of television and solid state devices saw Astor take up the opportunities offered by these new technologies, the company subsequently producing a wide range of TV sets and transistor radios. In fact, anyone who trained in "Radio and Television" at RMIT during the 1960s probably worked on the famous Astor SJ TV set.

It was during the 1960s that Astor was amalgamated with Pye which was then eventually absorbed into the giant Philips company.

Astor M5/M6: first look

Two interesting transistor sets produced by Astor during the 1960s were the M5 and M6 models, both featuring just five transistors. In my opinion, the M6's handsome plastic case puts it firmly into the so-called "Mid-Century Modern" school of design (from about 1940-1970). It's visually clean and unadorned, with none of the Art Deco scrolls or graceful rounded corners prominent in earlier times.

In addition, the M6's burnt-orange case, with white front insert, sits nicely in my kitchen. It's visually prominent without "shouting" its presence. On the other hand, the M5's red/black colour scheme is a bit too "loud" for my tastes.

Both sets feature direct-drive tuning which is operated by turning a large, clear plastic knob with a knurled edge. This allows stations to be quickly and accurately tuned. They are also both capable of producing a sound level that's easily heard throughout the room.

In short, clean design, good performance and ease of use make either an ideal mantel set.

M5 circuit details

Fig.1 shows the circuit details of the Astor M5. At first glance, it may appear somewhat confusing but the important thing to remember is that it uses PNP transistors throughout and has the negative DC supply rail connected to earth. Although this makes no difference to the circuit's operation, it does make some sections, especially the audio amplifier, a bit difficult to follow.

In addition, Astor simply numbered the components on its circuits in running order. However, this makes sense if you consider the assembly line workers. They didn't have to know whether a component was a resistor, a capacitor, a transistor or anything

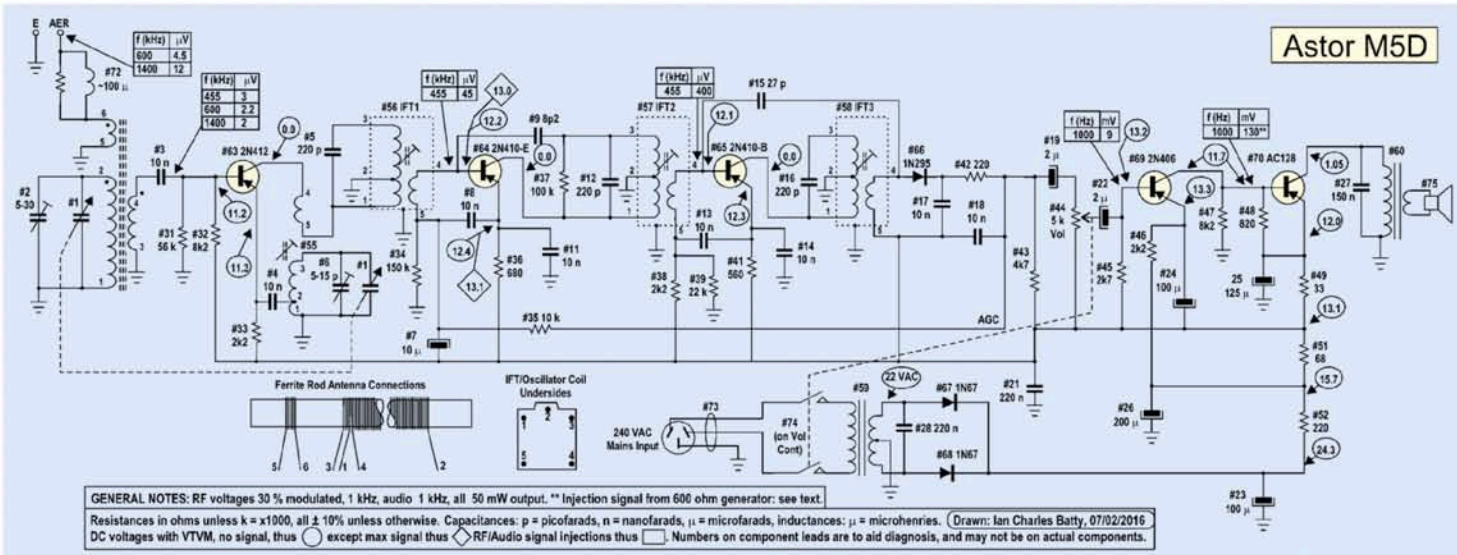


Fig.1: the Astor M5D's circuit uses five PNP transistors. Transistor #63 is the converter stage, #64 and #65 are IF amplifier stages, #69 is an audio driver stage and transistor #70 is a class-A audio output stage. Capacitors #9 and #15 are used to neutralise the two IF amplifiers, while the filtered output from diode demodulator #66 provides AGC to transistor #64.

else. All they had to do was match the vacant component positions on the PCB they were assembling to the component bin numbers.

Rather than reinvent the wheel, I've preserved Astor's original component numbering on the redrawn circuit presented here.

As shown, the tuned RF signal is fed to the base of the 2N412 converter transistor (#63). This stage operates with fixed bias and uses collector-emitter feedback. This, together with a cut-plate tuning gang (and thus no padder), is pretty much a standard design. The only addition is an aerial coupling winding on the ferrite rod, which is useful if you need to connect an external aerial.

There's no immediate sign of an antenna screw terminal or socket on the case but the designers have pulled a neat trick. The aerial and earth connections are both made via two case screws on the underside of the cabinet, close to the front. Fortunately, they are clearly labelled.

IF stages

The output from the converter is fed to the tapped, tuned primary of the first IF transformer (#56) and this in turn feeds the first first IF amplifier stage, a 2N410-E (#64). This is the AGC-controlled stage. It uses combination bias (emitter resistor #36, base divider resistor #34), while the AGC control voltage is derived from the demodulator via resistor #35.

Because the 2N410 transistor is an alloyed-junction type, its high collector-base capacitance requires neutralisation (ie, from collector to base). That's done using capacitor #9.

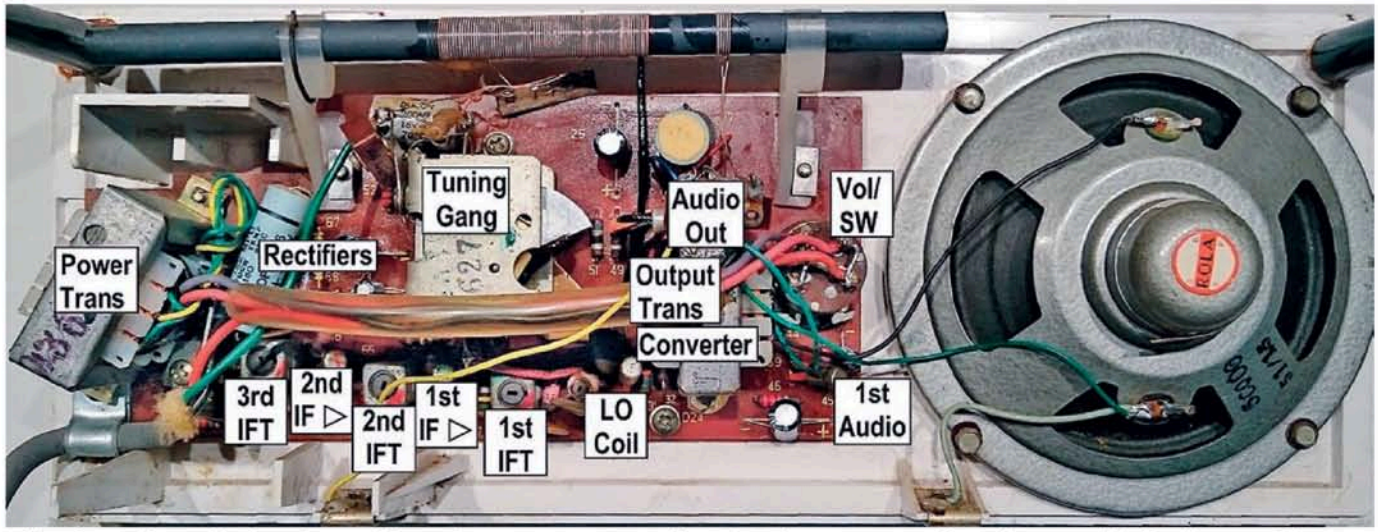
The second IF transformer (#57, IFT2) also has a tapped, tuned primary and feeds the signal to the second IF amplifier, in this case a 2N410-B (#65). This stage also operates with fixed combination bias. Note that IFT2's primary is shunted by a 100kΩ resistor (#37) to help broaden the IF bandwidth.

This second IF amplifier feeds a third IF transformer (#58, IFT3). Unlike IFT2, this last IF transformer is not shunted, as the loading of the following demodulator is sufficient to lower the primary winding's Q factor and broaden its bandwidth.

As with IFT1, the second IF amplifier (#65) is neutralised. That's done using capacitor #15 which is connected between IFT3's secondary and the transistor's base. This neutralisation capacitor has a value that's several times higher than that of capacitor #9 which is used to neutralise the first IF amplifier stage.

This is necessary due to its secondary IF connection; the signal is stepped-down which means that more

This photo shows the Astor M5 at left, while at right is the M6. They use the same cabinet but the colours and front panel details are different.



This photo shows the locations of the major components on the PCB. The parts are all easily accessible but be careful not to apply too much heat when desoldering parts from the board, as the copper pads are prone to separate from the laminate.

capacitance is needed for proper neutralisation.

The 1N295 diode demodulator (#66) is slightly forward biased by the first IF amplifier's bias resistor (#34). As the incoming signal strength increases, the diode produces a positive-going rectified signal current that partly opposes the current in this resistor. This in turn reduces the bias on the first IF amplifier stage and reduces its gain. Bypass capacitor #7 filters out audio signals to prevent them from affecting the AGC action.

Basically, it's a classic diode demodulator/AGC design, the only difference being the "upside-down" nature of the circuit due to the use of PNP transistors.

The demodulator drives the usual filter capacitors (#17 and #18), resistor (#42) and an audio load resistor #43. The recovered audio is then fed via capacitor #19 to volume control #44 and from there via capacitor #22 to the first audio amplifier stage (#69). This then drives the audio output stage (#70)

The audio section is direct-coupled, with DC-coupled feedback from the output transistor's emitter back to the driver transistor's base.

M5: simplified audio stage

The redrawn audio amplifier circuit shown in Fig.2 makes it somewhat easier to follow. Audio output transistor #70 (an AC128) gets its base current via resistor #47. At only 8.2kΩ and with around 11V across it, this could potentially provide almost 1.5mA of base current for transistor #70. That sounds like a lot and it would be except for the action of audio driver transistor #69 (a 2N406).

As the AC128's collector current builds (potentially to some 75mA or more), it also draws emitter current. This emitter current flows through emitter resistors #49 and #51.

As shown on Fig.2, the top of resistor #51 is connected via resistor #45 (2.7kΩ) back to the driver transistor's base. The resulting base bias causes collector current to flow in this transistor. As its collector current increases, the voltage across resistor #47 also increases and so transistor #69's collector voltage approaches its emitter voltage.

However, since transistor #69's collector voltage is also transistor #70's base voltage, the base bias applied to the latter falls. It's a classic DC feedback circuit, which will stabilise at a designated value; in this case, at a collector current of around 30mA in output transistor #70.

Emitter resistors #46 and #49 and base-emitter resistor #48 "trim" the DC conditions, while capacitors #24 and #25 provide emitter bypassing to prevent degenerative feedback from cutting the gain. Capacitor #27 rolls off the high-frequency response. This slightly reduces the distortion and helps to reduce the noise in weak signals.

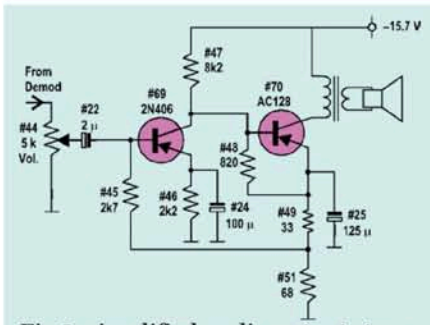


Fig.2: simplified audio output stage for the M5. It's a classic DC feedback circuit with output transistor #70 operating in class-A mode.

The AC128 (#70) operates as a Class-A stage. It drives output transformer #60 which in turn couples the amplified audio to a 5-inch (125mm) loudspeaker (#75). The set's power consumption is around 390mW, with around 330mW dissipated in the output transistor itself.

Note that although the AC128's maximum power rating is 1W, this rating only applies with adequate heatsinking. The AC128's thermal resistance from junction to ambient air (with no added heatsinking) is 290°C/W. Left with no heatsinking at all, a 1W power output at 25°C air temperature would send the transistor's junction to over 300°C and the device would quickly fail!

Astor's solution was simple: the transistor was fastened to a heatsink clip that was soldered to the output transformer's frame. That way, the output transformer also acted as a large heatsink for the output transistor.

The power supply uses transformer #59 to supply 22VAC (44VAC centre-tapped) to a full-wave rectifier based on diodes #67 and #68. Capacitors #23 and #26 and resistor #52 filter the output, while capacitor #21 provides RF filtering.

M6 circuit details

Astor's M6 "twin" is quite similar to the M5. Once again, it's a 5-transistor

design and its RF/IF section differs only as follows: (1) it uses NPN silicon transistors without neutralisation; (2) damping resistors are connected across the first and second IF transformer primaries; (3) different bias resistors are used to provide the higher base bias voltage needed by silicon transistors; (4) the first IF amplifier's emitter voltage drops from 0.6V to 0.2V on strong signals; and (5) there are no external aerial/earth connections.

The Astor circuit diagram indicates the use of an AT325 transistor for the converter, followed by three AT319s for the IF amplifiers and audio driver stage. An AX1167 is specified for the output stage. By contrast, my set uses Philips "lockfit" (SO-25) BF194/195 types and an OC9264 output transistor.

Another set that I've worked on used the specified AT-series transistors for the first four stages and a Fairchild AX1157 TO5 ceramic/epoxy device in the output stage. All sets used germanium demodulator diodes.

So why were the extra damping resistors used? The reason is that the silicon AT/BF series transistors have high output impedances – about five times that of the germanium 2N-series devices. So while the M5 was able to capitalise on the lower output impedances of its 2N-series transistors to help broaden the IF bandwidth, the M6 required damping resistors to achieve the same effect.

Simplified M6 audio stage

Fig.3 shows the Astor M6's audio stage. As with the M5, it's direct-coupled but the circuit is quite different. In this case, the driver transistor (#74) is an NPN device, while the output transistor (#75) is again a PNP device.

Resistors #46 and #45 form a voltage divider and this sets the bias on the driver transistor's base to 2V. Its emitter is connected to ground via resistors #52 and #54, while its collector current flows through resistor #49 and also through the base-emitter junction of the output transistor (#75). In fact, the driver stage could potentially pull over 1mA through transistor #75's emitter-base junction (resulting in a collector current of some 100mA or more through the output transistor) if not for resistor #54.

The voltage across this resistor increases as the output transistor's collector current builds (ie, the voltage at the top of the resistor is pulled closer to the 17.2V supply rail). This in turn reduces the voltage across resistor #52, thereby reducing the driver transistor's emitter-base voltage and thus its bias. As a result, the circuit stabilises with the output transistor collector current of around 30mA, as in the M5's circuit.

The 250µF bypass capacitor (#22) at the driver transistor's emitter removes any degenerative (gain-reducing) feedback in this stage. In addition, resistor #51 provides DC-coupled feedback, controlling the overall gain and effectively increasing the driver transistor's input impedance. This feedback also reduces audio distortion.

It's about as simple as you can get, yet it performs quite well. The only drawback, as with the M5, is the low efficiency of the Class-A output stage. However, in a mantel set which consumes just a few watts in total from the mains, it's a minor quibble.

Like the M5, output transistor #75 is fitted with a small flag heatsink that's attached to the power transformer.

M5 clean-up

My M5 was bought at a garage sale.

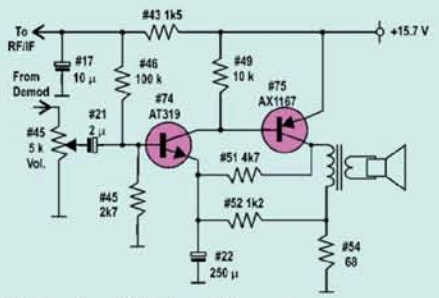


Fig.3: simplified audio output stage for the Astor M6. As with the M5, it's direct-coupled but, in this case, driver transistor #74 is an NPN device, while the output transistor (#75) is again a PNP device.

Unfortunately though, it wasn't working when I got it home; plugging it in and turning it on resulted in silence.

I turned on another set, tuned it to the top end of the broadcast band and was rewarded with a "swoosh" from its speaker as I varied the M5's tuning at the low end. This indicated that the M5's local oscillator (LO) was working and perhaps the rest of the RF/IF section as well.

I then opened the case and injected audio into various points in the audio stages. I found that I needed to inject some tens of millivolts into the output transistor's base in order to achieve a good output. However, I needed to feed even more into the volume control, so perhaps the driver transistor was dead?

The DC voltages around the driver stage subsequently checked out, so the transistor was OK. Instead, it turned out to be the usual suspects – dried-out coupling capacitors (#19 and #22). I ended up replacing all seven electrolytics in the set, just to make sure.

That done, I gave the set a quick alignment and a good clean, after

What To Watch Out For During Restoration

While changing the electrolytic capacitors in my M5 radio, I rather carelessly failed to completely desolder one of the circuit pads. When I subsequently wiggled the associated capacitor to remove it from the board, this pad lifted clear off the board.

Because of this, I suspect that the copper-to-board bonding is not especially good on these sets. My advice is to be careful and to take your time if doing repairs on M5 and M6 receivers.

Be aware also that the tuning knob is NOT a simple press-fit onto the tuning gang shaft, as it is with many other sets. Removing the tuning knob involves first prying off the centre gold/silver metal cap, then undoing three small screws that clamp the knob to a boss that's attached to the tuning gang's shaft.

Finally, note that the mains wiring in the M5/M6 is lacking in some respects. There's no grommet or strain relief where the mains cord enters the case and the mains wires inside the case are routed (through insulation) across the back of the metal tuning gang to the on/off switch on the back of the volume control. This volume control is fitted with a metal knob, while the metal boss in the centre of the tuning knob is in direct contact with the tuning gang.

For this reason, restorers are advised to check the mains wiring carefully, particularly the insulated tubing that carries the mains wires to the on/off switch. Make sure also that the circuit is correctly earthed.

Screw terminals for the external aerial and earth connections are hidden under the front edge of the cabinet. In most situations though, the set's internal ferrite rod antenna should provide adequate signal pick-up.

which it was right to go. By contrast, my recently-acquired Astor M6 model worked straight away and simply required a good clean and some alignment adjustments to optimise its performance.

How good is it?

Despite having just five transistors, the M5 is nearly as good as a conventional 6-transistor set with a push-pull output stage. Philips' marvellous Model 198 is better but the M5's provision of aerial and earth terminals (as was common with valve mantels) allowed it to also perform quite well in country areas.

The M5's sensitivity (50mW output) is 70µV/m at 600kHz and 45µV/m at 1400kHz for signal-to-noise (S/N) ratios of -10dB and -11dB respectively. A -20dB S/N ratio requires a signal strength of some 150µV/m at both frequencies.

At the aerial terminal, the sensitivity is 4.5µV at 600kHz and 12µV at 1400kHz for -10dB and -11dB S/N ratios respectively. The corresponding figures for a -20dB S/N ratio are 10µV and 38µV respectively. The loss of high-end gain is probably due to matching inductor #72 which has a value of 100µH.

The IF bandwidth measured ±2.3kHz at -3dB and ±31kHz at -60dB, which is reasonable. The AGC action is quite good, with the output rising by 6dB for a signal increase of some 22dB.

The audio response is 80-2600Hz from volume control to speaker and about 80-2200Hz from the antenna to the speaker. It gives 8% distortion at 50mW output, 3.5% at 10mW and 12% at 100mW with noticeable clipping. These distortion figures are consistent with single-ended Class-A output stages where (unlike push-pull output stages) odd-harmonic distortion is always present to some degree.

A note on testing

I've given signal injection voltages (as I do in all my testing) according to the generator output controls, as it's much easier than trying to measure the actual signal voltages in-circuit. However, this loses validity when injecting signals into the base of the AC128 audio output transistor.

In that case, the generator's 600Ω output impedance is attempting to drive the AC128's base impedance which may be only 100Ω. The result is a lower-than-indicated signal voltage being injected into the circuit.

The all-silicon M6

For the M6, we get similar sensitivities of 75µV/m at 600kHz and 33µV/m at 1400kHz for for 50mW output (S/N ratios of -12dB and -7dB respectively). Achieving a 20dB S/N ratio requires some 400µV/m at 600kHz and 150µV/m and 1400kHz.

The M6's IF bandwidth is ±2.6kHz at -3dB and ±27kHz at –60dB. Once again, the AGC action is quite good, with a signal increase of some 28dB necessary for an increase in output of 6dB.

The audio frequency response is 55-7300Hz from the volume control to speaker and around 50-2100Hz from the antenna to the speaker. The distortion is 1.5% at 10mW output, 2% at 50mW and 10% at about 120mW.

The lower distortion at lower output levels is testament to the use of negative feedback in the M6's amplifier stage.

In operation, the 5-inch loudspeaker, combined with a good-sized cabinet, gives acceptable low-frequency response down to about 100Hz.

"M" versions

Astor made other "M" version radios that were housed in the same case, eg, the look-alike M2 which was supplied with a separate remote speaker. This allowed normal radio listening (from the internal speaker), while the remote speaker allowed the unit to be used as an intercom or as a baby monitor. Radio listening via the remote speaker only was another option.

The M2 is a 7-transistor set, with four transistors used in the audio section to enable intercom operation. Two of these transistors were used in a push-pull audio output stage.

Would I buy another?

For the time being, I'm happy to stop with the M5 and M6 models I have, one of which is used as a kitchen radio. However, an M2 (preferably with its extension speaker) would be hard to pass up if any still exist. SC

Further Reading

(1) Special thanks to Kevin Chant for the original M5 and M6 circuits: www.kevinchant.com/astor.html

(2) Further information on the Astor M5 and M6 is on Ernst Erb's Radio Museum site: www.radiomuseum.org/r/astor_m5d.html

(3) For further information on direct-coupled bias circuits, refer to "Power Supplies and Biasing", Radio Waves, October 2015, pages 18-28.

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Digital Audio Volume Control PCB wanted

I'm hoping to make a Digital Audio Volume Control from the February & March 2007 issues but I don't wish to etch the boards as I have young children and don't have a location to store the chemicals that would be out of their reach.

I was wondering if the author would have an issue for me to use a PCB manufacturing company and if I do go ahead, if any of other readers would want a board too; the minimum order quantity ranges from three to 10 boards. (B. G., Kangaroo Flat, Vic.)

● We have no problem with you using a PCB company to get some boards made using the published artwork. Alternatively, since this project was subsequently published by the UK Magazine Everyday Practical Electronics (EPE), you should be able to purchase the two PCBs directly from them; EPE 714 & 716 at www.epemag.wimborne.co.uk/acatalog/EPE_online_catalog_PCB_Service_9.html

We can supply the programmed micro for that project.

However, while that digital volume control gave a reasonable performance we prefer the remote motorised volume control used in the Ultra-LD Mk3 Stereo Amplifier described in the November 2011 issue and also featured (in a slightly different guise) in the Currawong valve stereo amplifier in the January 2015 issue. It has much lower distortion and a better signal-to-noise ratio.

We can supply both the PCB and the programmed micro for either of those projects.

Anti-carjacking & vehicle tracking devices

Carjacking and aggravated burglaries have become a huge problem in Melbourne and surrounds – up 70% this year. Some years ago, SILICON CHIP published at least one circuit to cut fuel to the motor. Can this be updated, as there are so many new systems in today's cars capable of preventing a start, eg, if the automatic transmission lever is not in Park?

Aggravated burglaries are becoming more common, where intruders violently enter homes and demand keys to the family car (usually an expensive one). This is often used to hijack another, whereby they nudge a stopped car and when the driver gets out to investigate the damage, they are assaulted and the car taken.

There was an Australian company many years ago that had a system of tracking a car and at the same time, the police could remotely immobilise it. I have not been able to locate this firm. I have just purchased a new car. (R. T., Melbourne, Vic.)

● This is certainly becoming a problem for owners of late model prestige cars. However, there are plenty of GPS trackers available, as we found after a quick Google search. In addition, KCS Trade (see advert on page 17 of this issue) has a range of vehicle tracking devices using LoRa technology.

Internal transformer for the DAB+ tuner

I am considering adding a transformer to my DAB+/FM Stereo Tuner, as described in "Ask SILICON CHIP", December 2010. I am puzzled at the suggestion that I should use a centre-tapped transformer in place of the 9V plugpack. Why is this recommended?

What voltage should I use and would a 6V-0-6V transformer cause too much load on the 5V regulators? Would an Altronics M-4312 be suitable? (I. M., Geelong, Vic.)

● It is not mandatory to use a centre-tapped transformer. However, if you do and add in the extra diodes, it will have the advantage of reducing the hum and ripple on the power supply. It should be at least 15V CT (ie, 7.5V-0-7.5V) and this will give much the

Modifying A Power Supply For Float Charging Batteries

For many years now, I have used an ETI-111 regulated power supply. This is based on an LM723 which I initially used in the metal can package and more recently a dual in-line package (DIP).

I have been using the 15V taps on a multi-tap transformer and a wire-wound pot in place of R4 to regulate current (the article suggested several values for different current limits).

Recently, I bought a secondhand Ryobi drill with an 18V power-pack which I would like to keep on float charge. Is it possible to increase the maximum output of the attached circuit up to around 20V without a major redesign? There is a 17.5V tap on the transformer if needed.

Alternatively, I could build the MiniReg 1.3-to-22V regulator from the December 2011 issue of SILICON CHIP. The question then is how do I regulate the float current? I would appreciate any other suggestions. (B. L., Cranbourne, Vic.)

● We assume your Ryobi drill uses a Nicad or NiMH battery pack. If its charger is working, then we would recommend you build the Cordless Power Tool Charger Controller from our December 2006 issue. You can see a free 2-page preview of this story at www.siliconchip.com.au/Issue/2006/December/Cordless+Power+Tool+Charger+Controller

This would be a much better approach than simply having a variable supply based on an LM723 regulator. It will provide proper dT/dt (temperature rise) cut-out, with temperature sensing of the battery pack, time-out limit and trickle charging.

The PCB and programmed micro are available from our Online Shop.

Surface-Mount PCB Construction & Layout

I am building the Arduino ECG shield from the October 2015 issue. The NE5532 ICs from the SILICON CHIP Online Shop don't have any dot indicating pin one. The writing on the chip says p1hn 63. Is it correct to assume that this p1 refers to pin 1?

Also, I am wondering why this board is so congested. There seems to be a lot of space available but the SMD components are crammed together in about one third of the space. It would have been easier to solder if they were spaced more and also if common pads were used where components are joined. I have managed to do it with the aid of clamps and magnifying but not without a bit of cursing. (B. D., Mount Hunter, NSW.)

● SMD ICs in SOIC packages always have a bevelled edge along the pin 1 side. Look at the part from the top or bottom end and you should see it.

Regarding the PCB layout and packing of components, this is dictated by performance requirements. ECGs sense very small voltages with relatively high impedances so there are serious issues such as RF pick-up, parasitic coupling between tracks, interference between power supply and analog paths and so on, which need to be addressed to get good performance.

One of the easiest ways to solve most of these problems is to put the components in close proximity so that the tracks lengths are minimised. Each track acts like an antenna and also an inductor. Shorter tracks are less likely to pick up radiation and also have less parasitic inductance and capacitance. So overall you will have fewer performance problems in this sort of circuit by keeping the components close together.

same DC input to the 5V regulators. You can use an Altronics M-2155L.

If you simply want to use a 9V transformer and not add in the extra diodes, that will provide the same effective power supply as in the original circuit. In that case, use an Altronics M-2840L and ignore its centre-tap connection.

The M-4312 is not suitable as it is intended for PCB-mounting and its output voltage is not high enough.

Mains frequency meter project wanted

I was wondering if SILICON CHIP has ever done a project for a mains frequency meter. This would show the frequency at 230VAC and would be used for testing the frequency of a generator (technically an alternator). It could also incorporate a voltmeter as well.

Have you given any more thought to a cordless phone back-up power supply, which would maintain power to a cordless phone during periods of extended blackouts? It's been suggested to use a UPS but a UPS is not suitable for this purpose, being designed to output a higher current for a short period and shut down after an hour or two, so is useless when the power is off for six or seven hours during line maintenance. (B. P., Dundathu, Qld.)

● We have not published a mains frequency meter and we doubt whether such a project would be a viable proposition since there are many multimeters which perform these functions. And as you have no doubt noticed by now, we published the first of two articles on an Appliance Energy Meter in the August 2016 issue. Among many other parameters, it displays the mains frequency and voltage.

We have not produced a cordless phone back-up supply. The difficulty in designing such a device is that cordless phones on the market run from a range of DC and AC voltages which means that the backup supply really needs to provide a 230VAC output.

If a UPS won't do the job it may be possible to have a DC-DC step-up circuit to provide 9-20V DC to drive the low voltage AC inputs on most cordless phones. We will investigate this possibility.

Precision Turntable Driver queries

I live in Greece (230VAC) and I'm about to build this motor driver so I will need your advice and your help about some parts. My turntable is an old Lenco L75 (idler-drive) and from the information I've collected about this turntable, it uses a high load/torque motor.

So based on that, I have a question about the power transformer. Can I use a more powerful transformer than the suggested one (20VA) in your part list? I'm planning to use a 160VA or higher-rated toroidal transformer to minimise voltage drop as much is possible, so is a more powerful transformer (160VA or more) acceptable?

It is assumed that a bigger enclosure is needed but I have a no problem with that because I can make one very easily with a pair of heatsinks too.

My next question is is about the regulator (7805). Can I use an LM317 instead? Of course, a resistor will need to be added to set the output of the LM317 to 5V. Is this modification acceptable?

The last thing I'd like to ask is about the values of the polyester and ceramic capacitors in the parts list. What AC or DC voltage rating is required? Thanks in advance. (N. L., Greece.)

● The power output is mainly restricted by the driver stage to the transformer and we rated it for 20VA. We think that 20VA is more than adequate for a turntable and the high load torque motor description does not necessarily mean you need 160VA. As it stands, the design is not suited to drive a 160VA tranformer. That is an eight-fold increase in output power and is not achievable without significant circuit changes.

There is no reason to use an LM317 instead of the 7805 regulator although you could probably do so. The PCB does not accommodate this part and its extra resistor requirements. The polyester and ceramic capacitors can be rated at 50VDC. The X2 rated capacitor is mains voltage rated (typically 250VAC).

Improved parts for the 10V DC Reference

Regarding the 10V DC Reference from the March 2014 issue, can I substitute the REF102CP for the AD-587KNZ? It appears to have twice the innate accuracy and I have no means of trimming the voltage accurately. Also, is the CD4541BE the correct timer chip?

Both are element14 parts. By the way, the AD587KNZ appears to be in run-out. (R. A., Melbourne, Vic.)

● That seems like a good scheme and the REFC102CP is a better chip.

We draw your attention to the sim-

Little Torque From Induction Motor At Very Low Speeds

I'm using the 1.5kW Induction Motor Speed Controller, to drive a small (0.25kW) 3-phase motor. The torque output drops to very low levels during low-speed operation (10Hz).

The motor is delta-wired but I suspect the voltage provided by the controller is reduced too much at low speeds to suit this small motor. The system works well at higher speeds.

Can you suggest how I might improve the torque output at lower speeds? I am familiar with "field-oriented" drives, which allow up to 150% of rated torque at zero speed! (I. T., Duncraig, WA).

- In normal operation of the software, the voltage will be substantially reduced at 10Hz to avoid current overload because the motor's impedance is a product of frequency and inductance. The motor impedance at 10Hz will only be 20% of the value at 50Hz and therefore the voltage must be reduced substantially to avoid overloading the speed controller. Unfortunately, this will inevitably reduce the available torque.

plified version of this circuit which we published in the August 2014 issue. This eliminates the 4541 chip because its oscillator runs continuously and therefore it draws current even when not triggered by the Start switch (S1).

FM radio accidentally constructed

I've used a BF115 VHF transistor to build a 2-transistor RF/AF regenerative radio for shortwave reception but the FM/NBC station at Narwee is popping up through the tuning range. I live about 4km away from the transmitter.

The circuit has voltage-divider biasing to the base. Would a 100Ω stopper resistor between the voltage divider and base of the BF115 prevent this?

I have built one radio but can't modify it (there's no room) so should I build another, this time with the 100Ω stopper resistor? Looking forward to your possible solution please. (D. S., Penshurst, NSW.)

- Stopping breakthrough of a strong local FM station into a simple AM regenerative radio could be quite difficult. While an AM radio is not supposed to work with 100MHz signals, it is possible via a phenomenon known as "slope detection". You somehow have to stop the circuit responding to these very high frequency signals.

It's not possible to suggest cures without knowing the details of your circuit but a stopper resistor in series with the base of the first transistor would be a good place to start.

Ultrasonic Anti-Fouling unit blowing fuses

I bought an Ultrasonic Anti-Fouling kit from Jaycar (September & November 2010) and I'm having issues with it. I followed the instructions carefully while building it. I have measured all the resistor values and the diodes and capacitors all check out. I have had a good look at the pre-wound transformer and it seems to be as per the instruction sheet. I have no way of checking the chips or the Mosfets.

I'm using a Dick Smith 12V power supply. I have adjusted the regulated voltage to 5V as per the instructions, with the fuse and IC2 removed. The 5V supply seems stable. With IC2 and the fuse fitted and the transducer connected, the fuse blows immediately the power is turned on.

I have read on a forum that others have had similar issues and the answer for them was a higher-rated slow blow fuse. One guy used a strand of wire as a fuse. It seemed to work for them but this did not solve my problem; in fact, it made it worse as it allowed the Mosfets to burn out along with the track between the fuse and the switch. I have since fixed this but it still doesn't work.

I checked the board tracks against the magazine drawing and it is the same except that the terminals have been rotated. I also checked and re-

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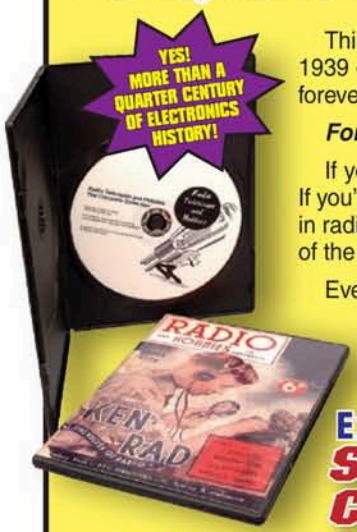

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Operating Capacitors Well Below Rated Voltage

I have a question regarding electrolytic capacitor voltage ratings. Nearly 50 years ago when I worked in the black and white television service industry, we experienced a spate of electrolytic capacitor failures, typically in the cathode bypass role in areas like the vertical output stage. The capacitors were generally 100µF and rated at 25V (working) or thereabouts.

A number of service technicians started replacing these capacitors with 100µF 250V units, which were very common in this sort of TV set. However, it wasn't long before the 250V capacitors were failing at a greater rate than the 25V ones.

Investigations with capacitor manufacturers led to the theory that an electrolytic capacitor needed to have a voltage applied to it within reach of its rated voltage in order for the electrolyte to form properly. If this was not done, premature failure would result. I don't know if this theory was correct but reverting to the specified voltage ratings seemed to cure the problem.

My question is, therefore, do you know if this theory of capacitor electrolyte formation is correct and if so does it still apply today? In other words, am I risking premature failure if I discard my 16V electrolytic capacitor stock in favour of, say, 50V capacitors which would greatly reduce the number of components I keep on hand? (B. D., Hope Valle, SA.)

● We can't think of any reason why a 250V capacitor would have a higher failure rate than a 25V-rated unit, when operated at a voltage below 25V. Besides the possibility that the 250V capacitors were simply inferior in some way (eg, a different electrolyte formula or concentration), the only possible explanation might be that the AC currents being bypassed by the capacitor were much higher than its ripple current rating. This could possibly happen in the cathode circuit of a TV's vertical output stage, given that it would be handling the relatively high 50Hz currents applied to the deflection coils of the yoke.

As for the necessity to "form" the oxide dielectric layer of an electrolytic capacitor, there is some truth in that but the chemistry of the electrolyte in today's electrolytics is much improved on those from 50 years ago so it is not such an issue. Furthermore, the capacitors do not deteriorate to such a great extent when left for years without use.

So if you really do want to cull your stock of capacitors, you can toss the lower-rated ones. Bear in mind though that some 50V capacitors will be larger than their 16V equivalents and that might present a problem in some tightly packed PCBs. Also consider that if the 50V rated capacitors are a similar size to the 16V types, they may have inferior specifications such as rated temperature, ripple current rating, ESR or lifespan.

checked all my solder joints, both visually and with my meter, as well as reheating the joints to make sure.

I have replaced all the diodes, capacitors and both the Mosfets. I did not replace the resistors as they still measure OK. I bought a new regulator but the replacement Jaycar sent is a different part number and I could not adjust the output to 5V, so I reinstalled the original. Jaycar would not sell me a replacment programmed microcontroller (IC2) so I could not try that.

Given all this, I can only guess that one of the ICs is the problem. I would appreciate any ideas that you might have. (R. A., Crestmead, Qld).

● It sounds like the 5V supply is OK. You could check the drive to the Mosfet gates by removing the fuse and powering up. You should be able to measure a DC voltage at the gates of the Mosfets with respect to ground.

The voltage should go above 0V and since the DC voltage will be an average of the pulses, it will settle at about 2V. That's not the best test but gives an idea if the Mosfets are being switched. An oscilloscope will show whether the Mosfets are being correctly driven in anti-phase.

One problem that can cause a blown fuse is if the large low-ESR electrolytic capacitor is faulty. Another is if one of the IC pins is bent up under the socket for IC2 and so not making contact. A much less likely cause is a faulty PIC12F675 or programming error.

You can get a replacement programmed PIC for the unit by contacting kits@jaycar.com.au

Charging gel cell batteries

It may be a silly question but I've forgotten if it's OK to use a lead-acid battery charger designed for car batteries (Thunderbird Battery Charger) on a 12V gel cell. I do have the gel cell charger that SILICON CHIP designed a long time ago but it's buried in my lock-up storage shed. I'd like to avoid digging for it, if I can. (P. V., Hazelbrook, NSW).

● Provided your Thunderbird Charger is adjusted to provide a maximum output of 13.6V when set to charge 12V batteries, it should be fine to charge 12V SLA (gel cell) batteries.

Horizontal trimpots for MPPT Solar Charger

I am purchasing components to build the Solar MPPT Charger & Lighting Controller from the February & March 2016 issues of SILICON CHIP. Can you give me a little more detail on the type/brand of mini horizontal trimpots in your parts list on page 36 of the February edition? I'm not sure whether they are of the open carbon type, Cermet 1-turn type or Piher style. Your photo on page 37 suggests Cermet types. (R. C., Freshwater, NSW.)

● We use the Piher-style trimpots with 5mm (5.08mm) pin spacings, eg, Jaycar RT4360 (10kΩ) and RT4362 (20kΩ), Altronics R2480B (10kΩ) and R2481B (20kΩ). Cermet 3386F types can also be used, such as Altronics R2597 and R2598.

Programming the Spacewriter

I have been given an old Spacewriter kit originally sold by Jaycar Electronics. I would like to build it but note that the TMS6264L is programmed via a parallel printer port. As I have a laptop with USB and no printer port, is there a way I can program the device using a USB cable? I don't want to proceed if I cannot program it. (R. B., NZ).

● Technology has certainly changed

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since the Spacewriter was designed. You could still program it if you obtain a parallel printer port to USB converter. Jaycar sell these (www.jaycar.com.au/usb-to-parallel-bi-directional-cable/p/XC4847) and there are plenty of other suppliers if you do a search for parallel printer port to USB converter.

Why Jacob's Ladder must be battery-powered

I'm currently building Jaycar's Jacob's ladder kit of your February 2013 design and I'm very curious as to why I shouldn't run this off the 230VAC mains. I'm thinking of using a 12V DC plugpack with a 56,000µF capacitor bank.

Is it an issue of spikes getting back onto the mains? Or rather of high voltage (230VAC) being in the kit? (R. R., NZ.)

● Running from the mains could reduce safety should the circuit 0V be connected to Earth, or due to a breakdown in the mains transformer or isolation failure in a switchmode supply. The high-tension voltage generated could spark back through the mains through such a fault or via a low impedance path (eg, water),

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Next Issue

The October 2016 issue is due on sale in newsagents by Thursday 29th September. Expect postal delivery of subscription copies in Australia between 29th September and October 14th.

Ask SILICON CHIP

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causing insulation breakdown. Having a fully floating supply that is not Earth-connected and that does not have the possibility of becoming live via the mains is the safest option.

The high-tension voltage is considerably dangerous on its own without added safety compromises.

Can't get Multi-Spark CDI to work

I've bought your December 2014 and January 2015 magazines, hard to get parts, etc and made the High Energy Multi-Spark CDI Ignition, designed by John Clarke.

I am using a reluctor pickup system and I installed the unit and tried to set it up as per the January 2015 article (as described under "Testing") . With all wires connected (except the tacho), I was able to set the output to 300V DC but adjusting the pick-up sensitivity has been different to what has been explained.

Looking at my unit in the same way as the diagram on page 41, I adjusted VR2 as described but mine seems to work back-to-front, though my trimpot is facing the same way as in the diagram.

I could only adjust Q7's collector (top leg, just under the "Q7" label) to 4.44V max, not 5V plus the two extra turns as described.

I drove the vehicle anyway and it seemed to run really well for approximately 15 minutes and then as I entered the freeway and accelerated, I suddenly got a lot of misfire and popping and the vehicle subsequently would only idle roughly.

While stationary I tried to accelerate from idle but it stalled. I noticed while idling that the alternator cap sounded like there was a lot of unusual arcing going on inside that wasn't there before. I switched back to the vehicle's original ignition system which is working fine.

I would really like some help as to what's going on. (R. O., Balga, WA.)

● The trimpot setting for the reluctor is possibly the problem. Try adjusting VR2 when the reluctor is warmed up or when the engine runs poorly.

The 470pF capacitor connected across the reluctor may also need to be increased to remove any misfiring due to alternator noise. Try a 1nF or 2.2nF capacitor.

Dual-channel audio delay unit wanted

I have been searching the internet for audio delay modules. I've come across some projects in SILICON CHIP that look great.

Can these be bought as a complete kit? I would want three or four of them. (D. H., via email.)

● There are no kits for the Dual-Channel Audio Delay project from the November 2013 issue but we do have the PCB, the programmed micro and the codec IC available on our on-line shop at www.siliconchip.com.au/Shop/?article=5450 SC

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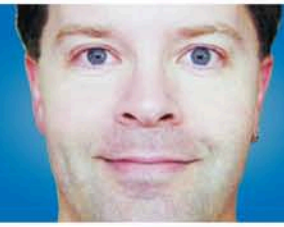

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